CHROMIUM

By John F. Papp

Domestic survey data and tables were prepared by Joseph M. Krisanda, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2004, the U.S. chromium supply (measured in contained chromium) was 168,000 metric tons (t) from recycled stainless steel scrap, 326,000 t from imports, and 570,000 t from Government and industry stocks. Supply distribution was 34,700 t to exports, 474,000 t to Government and industry stocks, and 555,000 t to apparent consumption. Chromium apparent consumption increased by 4.0% compared with that of 2003.

The United States exported about 88,614 t, gross weight, of chromium-containing materials valued at about $80.7 million and imported about 648,096 t, gross weight, valued at about $477 million.

Domestic Data Coverage

Domestic data for chromium materials were developed by the U.S. Geological Survey (USGS) by means of the monthly "Chromite Ores and Chromium Products" and "Consolidated Consumers" consumer surveys. High-carbon ferrochromium is the most consumed chromium-containing material. Stainless and heat-resisting steel producers accounted for most of the chromium-containing material consumed.

Legislation and Government Programs

The Defense National Stockpile Center (DNSC) disposed of chromium materials under its fiscal year (FY) 2004 (October 1, 2003, through September 30, 2004) Annual Materials Plan (AMP). The FY 2004 AMP (as revised in May) set maximum disposal goals for chromium materials at 99,800 t of chromium ferroalloys, 90,700 t of chemical-grade chromite ore (or remaining inventory), 90,700 t of refractory-grade chromite ore (or remaining inventory), and 454 t of chromium metal (Defense National Stockpile Center, 2004). The FY 2005 AMP maximum disposal goals for chromium materials were the same as those for FY 2004 AMP (revised) (Defense National Stockpile Center, 2005).

Production

The major marketplace chromium materials are chromite ore and chromium chemicals, ferroalloys, and metal. In 2004, the United States produced chromium ferroalloys, metal, and chemicals, but no chromite ore. The United States is a major world producer of chromium chemicals and metal and of stainless steel.

Consumption

Chromium was consumed in the United States in the form of ferrochromium by the metallurgical industry in 2004. Ferrochromium was consumed principally to make stainless steel; however, it was also consumed to make chromium metal. In the metallurgical industry, the principal use of chromium was in production of stainless steel. Other important uses for chromium include the production of ferrous and nonferrous alloys (table 2). The domestic chemical industry consumed chromite ore and concentrate. Chromium has a wide range of uses in the chemical, metallurgical, and refractory industries. The chemical industry consumed chromite for the manufacture of chromic acid, sodium dichromate, and other chromium chemicals and pigments. A wide range of chromium chemicals is made from sodium dichromate. Chromite sand was used as refractory sand in the casting industry.

Prices

Chromium materials are not openly traded. Purchase contracts are confidential information between buyer and seller; however, trade journals report composite prices based on interviews with buyers and sellers, and traders declare the value of materials they import or export. Thus, industry publications and U.S. trade statistics are sources of chromium material prices and values, respectively.

More than one-half of U.S. ferrochromium imports and world production came from South Africa where the value of the rand per U.S. dollar decreased from about 6.9 in January to about 5.7 in December, a drop of 17%. Since the cost of production in South African rands needs to be accounted for in the price of ferrochromium in U.S. dollars, about one-third of the price increase resulted from the strengthening rand. Other factors were reported to have been strong demand from China and an increase in coke, electrical energy, and transportation costs. It was anticipated that coke and transportation costs would remain high until the bulk carrier fleet and port and loading facilities could be expanded to meet the increased rate of iron and steel production that resulted from the economic growth in China.

World Industry Structure

The chromium industry comprises the mining of chromite ore and the consumption and production of chromium chemicals, metal, and refractories, ferrochromium, and stainless steel.

Reserves.—The United States has no chromite ore reserves. However, the United States has a reserve base and resources that could be exploited. The U.S. reserve base is estimated to be about 10 million metric tons (Mt) of chromium. Reports on world chromium resources were published by the U.S. Geological Survey in 1984 and by the U.S. Bureau of Mines in 1993 (DeYoung, Lee, and Lipin, 1984; Boyle, Shields, and Wagner, 1993); in each case, one group of researchers applied one set of criteria to multiple deposits, a situation that lent consistency to the estimates. Economic, political, and technological conditions have changed significantly since then. The only current source of world chromium reserve and resource estimates is now from mining companies having a diverse group of analysts applying differing criteria to multiple deposits.

Production.—The International Chromium Development Association reported that world chromite ore production in 2004 was about 17.2 Mt, of which about 92% was produced for the metallurgical industry; 4.4%, for the chemical industry; 2.9%, for the foundry industry; and 0.5%, for the refractory industry (International Chromium Development Association, 2005, p. 1).

Stainless Steel.—The International Stainless Steel Forum reported 2004 world stainless steel production to be 24.6 Mt, an increase of 7.5% compared with that of 2003 (International Stainless Steel Forum, 2005§[1]).

World Review

European Union.—The European Union (EU) planned to limit marketing and use of cement that contains more than 2 parts per million of hexavalent chromium. Chromium finds its way into cement through chromium in raw material used to make cement, chromium steels used in crushing equipment, and chromium in the refractory lining of the cement roasting kiln. The high-temperature roasting environment of the cement kiln converts a portion of the chromium in cement into hexavalent chromium.

The EU planned to implement its restriction of hazardous substances (also known as RoHS) directive in 2006 (European Union, 2003). The directive also limits the chromium content of electrical and electronic equipment to 0.1%. Chromium exists in four valence states, divalent, hexavalent (valence of +6), metallic, and trivalent. Many hexavalent chromium compounds are hazardous. The major effect of this ban could be on chromate (a hexavalent chromium compound) coatings applied to zinc plating. (Stainless steel will not be affected because the chromium alloyed in the steel is in the zero or metallic valence state and the chromium in the surface layer is trivalent.)

Albania.—Albania produced chromite ore and ferrochromium. Darfo S.p.A, an Italian company holding a chromite ore mining concession, planned to invest €17.8 million ($22.1 million) in chromite ore exploration (Metal-Pages, 2004a§).

Australia.—Consolidated Minerals Limited produced chromite ore at the Coobina Mine in Western Australia through its wholly owned subsidiary Pilbara Chromite Pty. Ltd. Consolidated Minerals reported chromite ore production of 73,731 t in 2002, 76,237 t in 2003, and 243,221 t in 2004 from open pits using hydraulic excavators and dump trucks. Pilbara blended ore from multiple pits, and then crushed, screened, and used heavy-media separation to beneficiate the ore (Consolidated Minerals Limited, 2004, p. 9).

Australia reported chromite ore production of 22,668 t in 2002, 67,271 in 2003, and 104,317 t in 2004 (Government of Western Australia, 2005§).

Brazil.—Brazil produced chromite ore, ferrochromium, and stainless steel. Brazil reported that it produced 404,477 t of chromite ore [39.7% chromic oxide (Cr_2O_3)], exported 32,000 t of chromite ore (16,000 t Cr_2O_3 content), and imported 71,319 t of chromite ore (32,000 t Cr_2O_3 content). Brazil produced from a chromite ore reserve containing about 6.94 Mt, Cr_2O_3 content. In 2003, Brazil produced 204,339 t of chromium ferroalloys, of which 156,000 t was high-carbon ferrochromium, 10,000 t was low-carbon ferrochromium, and the remainder was ferrochromium-silicon. Brazil imported 10,652 t of ferrochromium and exported 156 t of ferrochromium (Gonçalves, 2004§). Based on production of chromite ore and trade of chromite ore and chromium ferroalloys, Brazilian chromium apparent consumption in 2003 was 261,000 t. Expansion of Brazilian stainless steel production capacity was expected to increase domestic demand for domestically produced ferrochromium.

Cia de Ferro Ligas da Bahia (Ferbasa) is the major Brazilian chromium ferroalloy producer (Ferbasa, 2005§). Ferbasa reported high-carbon ferrochromium production of 118,701 t in 2002, 160,816 t in 2003, and 158,222 t in 2004; and low-carbon ferrochromium production of 10,522 t in 2002, 10,441 t in 2003, and 19,054 t in 2004.

Canada.—Canada reported chromium metal imports of 69,600 kilograms (kg) in 2003, 5,191 kg in 2002, and 79,641 kg in 2001; exports of 6,772 kg in 2001, 5,191 kg in 2002, and 60,990 kg in 2003 (Natural Resources Canada, 2005§).

China.—China has emerged as a world economic driving force as it has displaced the United States as the world's leading consumer of many raw materials, such as coal and steel, and its consumption of other raw materials, such as oil, is increasing. Worldwide, stainless steel production accounts for most chromium consumed. In China, stainless steel production and production capacity were growing. China's stainless steel apparent consumption increased by 14% in 2000, 30% in 2001, 42% in 2002, and 31% in 2003 (Platts Metals Week, 2004). China's stainless steel production capacity was about 3.3 million metric tons per year (Mt/yr) with an additional 5.5 Mt/yr planned to come into production by 2010. This growth accounted for China's having become the destination of most growth in world chromium production. China's production of chromite ore was inadequate to meet its needs, so, in addition to importing chromite ore for domestic conversion to ferrochromium, it imported ferrochromium. Ferrochromium production is electrical-energy intensive, and China anticipated electrical power shortages through 2006. Accordingly, ferrochromium producers limit their production to offpeak hours. In order to improve power efficiency of production and reduce environmental

[1]References that include a section mark (§) are found in the Internet References Cited section.

impacts, China planned to close ferrochromium furnaces operating at transformer capacity below 3,200 kilovoltamperes (kVA); then to close those below 5,000 kVA.

From 1958 to 2003, when production based on chromite ore from Vietnam started, China's combined chromium chemical production capacity evolved to 320,000 metric tons per year (t/yr) from 24 plants. Production was about 226,900 t of sodium dichromate in 2003. Chinese sodium dichromate consumption grew to 230,100 t in 2003 from 61,800 in 1991, most of which was used to make chromic acid. During the same time period, chromic acid consumption grew to 82,600 t from 4,600 t. Consumption was projected to reach 360,000 t of sodium dichromate and 140,000 t of chromic acid by 2010. Only 6 of China's sodium dichromate-producing plants have production capacity of more than 20,000 t/yr; the plants account for more than 50% of production (Bi, 2004).

Ferrochromium production in China increased to 632,000 t in 2003 from 337,000 t in 1991. Ferrochromium production by year was reported to have been: 1992, 451,400 t; 1993, 421,400 t; 1994, 426,900 t; 1995, 764,000 t; 1996, 541,300 t; 1997, 572,600 t; 1998, 392,100 t; and 1999, 338,500 t; and 2000, 445,000 t. China produces ferrochromium from chromite ore supplied mostly by Kazakhstan and South Africa for use by its stainless steel producing industry, which has grown rapidly since 1990. Stainless steel production in China grew to 1.8 Mt in 2003 from 0.29 Mt in 1998 (1999, 0.5 Mt; 2000, 0.8 Mt; 2001, 1 Mt; and 2002, 1.25 Mt). Stainless steel production capacity grew to 3.3 Mt in 2004 and was expected to grow to 8.8 Mt in 2010. Demand for ferrochromium was expected to grow from 720,000 t in 2004 to 1.660 Mt by 2010, of which 60% to 70% was expected to be supplied by domestic producers. As a result, China was expected to become the leading world consumer of ferrochromium (Zheng, 2004).

Stainless steel consumption in China reached 4.2 Mt in 2003 from 0.26 Mt in 1990. China surpassed the United States as the world's leading stainless steel consumer in 2001 when apparent stainless steel consumption reached 2.25 Mt. From 1990 through 1999, Chinese stainless steel production varied between 200,000 and 400,000 t/yr, and then expanded to 1.778 Mt/yr in 2003, making China the fourth ranked producer after Japan, the United States, and the Republic of Korea. As demand for stainless steel has exceeded domestic production, China has imported stainless steel. China became the largest stainless steel importer in 1999 when imports exceeded 1 Mt. In 2003, stainless steel imports exceeded 2.962 Mt. China planned 7% annual growth rate in gross domestic product (GDP) would result in stainless steel production capacity growth to 6.5 Mt/yr by 2010. China anticipated meeting most of its ferrochromium demand through imports (Li, Cheng, 2004).

Campbell (2004) reported that in 2003 China produced 197,000 t of chromite ore, 533,000 t of ferrochromium, 227,000 t of sodium dichromate, and 5,000 t of chromium metal.

Baosteel produced stainless steel at No. 1 Steel Company (750,000 t/yr capacity) and No. 5 Steel Company (300,000 t/yr capacity) and planned to produce at Ningbo Baoxin Co. (600,000 t/yr capacity under construction). Baosteel planned to reach production capacity of 1.7 Mt/yr in 2005 (Zhang, 2004).

In 2004, China imported 2,147,691 t of chromite ore compared with 1,779,346 t in 2003, 276,668 t of high-carbon ferrochromium compared with 89,316 t in 2003, and 36,754 t of low-carbon ferrochromium compared with 26,428 t in 2003, and exports of 62,287 t of high-carbon ferrochromium compared with 83,156 t in 2003, 9,358 t of low-carbon ferrochromium compared with 13,624 t in 2003, and 137,996 t of stainless steel scrap (TEX Report, 2005c-e, g).

Li reported that abundant coal resources were being exploited for thermal power in the Erdos-Hohehot-Baotou area of Inner Mongolia along the Yellow River as part of the region's development plan. Communication, land, transportation, and water resources were available in the region to develop thermal electrical power from coal resources, a situation ideal for electrical-energy intensive production processes, such as ferrochromium production (Li, Shirong, 2004).

Durrant (2005) estimated that growth in Chinese stainless steel slab production capacity would peak in 2007 when nearly 2 Mt would be added. From 2004 through 2009, Durrant expected Chinese average annual stainless steel production growth to exceed 26.8% compared with world growth of 5%. China was projected to account for 85% of world growth in stainless steel slab production capacity and 80% of production by 2009, when world production was projected to exceed 31 Mt. In 2004, China was the fourth ranked ferrochromium producer and the only producer among the top five that did not have a significant domestic ore supply.

Finland.—Finland produced chromite ore, ferrochromium, and stainless steel. Outokumpu produced 580,000 t of marketable chromite ore from 1.2 Mt of run-of-mine ore and 264,000 t of ferrochromium in 2004 compared with 549,000 t of chromite ore from 1.1 Mt of run-of-mine ore and 250,000 t of ferrochromium in 2003. Outokumpu reported chromite ore proved reserves, in accordance with the Joint Ore Reserves Committee (JORC) of the Australasian Institute for Mining and Metallurgy code for reporting mineral resources and reserves to be 51 Mt graded at 25% Cr_2O_3. Outokumpu reported 4 Mt at 28% Cr_2O_3 measured, 13 Mt at 29% Cr_2O_3 indicated, and 77 Mt at 29% Cr_2O_3 inferred mineral resources. Outokumpu reported a stainless steel melting capacity of 1.65 Mt/yr at its Tornio works (Outokumpu, 2005§).

Riekkola-Vanhanen (1999) studied the environmental characteristics of the Outokumpu ferrochromium production process as measured in 1997 and compared them with the other available technologies and practices. Outokumpu's process was found to emit, for dust, 80 to 120 grams per metric ton (g/t) of ferrochromium (FeCr) produced; for carbon dioxide, 500 to 700 g/t FeCr; for nitrogen dioxide, 0.8 to 1.2 g/t FeCr; and for sulfur dioxide, 0.3 to 0.5 g/t FeC; the study also evaluated an increase in furnace production capacity of 20% through the use of preheating feed materials. Energy recovery was equivalent to 45,000 to 50,000 barrels per year of oil. In comparison with the other processes studied, the Outokumpu ferrochromium production process was found to have been the best available technology.

France.—Arcelor, one of the world's major stainless steel producres, purchased J&L Specialty Steel (United States) in 2003 and closed its stainless steel-producing plant at L'Ardoise. Arcelor reported 2.4 Mt of stainless steel production in 2004, down from 2.6 Mt in 2003 (Platts Metals Week, 2005).

Arcelor's view of the world stainless steel industry was that, from 1978 through 2003, world stainless steel production grew at about 6% per year; however, conversion costs have been decreasing by about 3% to 4% per year (Gilet, 2004). Stainless steel price is sensitive to raw material costs, such as those of chromium, molybdenum, and nickel.

Germany.—Elektrowerke Weisweiler GmbH produced low-carbon ferrochromium from Turk Maadin Serketi (Turkey) chromite ore at the rate of about 30,000 t/yr. Elektrowerke Weisweiler was purchased along with the Turkish chromite mines by Kermas Group (United Kingdom) through its trading company DDK Trading, which managed Serov Ferroalloys Plant (Russia), another low-carbon ferrochromium producer.

India.—India produced chromite ore, ferrochromium, stainless steel, and chromium chemicals. Electrical power availability limited ferrochromium production.

India reported that 19 mines collectively produced 1,548,900 t in FY 2002 (April 1, 2001, through March 31, 2002), 3,068,631 t in FY 2003(April 1, 2002, through March 31, 2003), and 3,199,462 t of chromite ore in FY 2004 (April 1, 2003, through March 31, 2004) from a chromite ore recoverable reserve of 97.076 Mt (Indian Bureau of Mines, 2004§). India reported chromite ore exports of 1,181,792 t in FY 2002, 1,098,343 t in FY 2003, and 35,849 t in FY 2004. India reported chromite ore imports of 54,567 t in FY 2001, 24,799 t in FY 2002, and 7,339 t in FY 2003. India reported ferrochromium exports of 125,134 t in FY 2001 and 66,138 t in FY 2002. India reported ferrochromium imports of 24,799 t in FY 2001 and 7,339 t in FY 2002. Based on the chromite ore production and chromite ore and ferrochromium trade, Indian apparent chromium consumption in FY 2002 was 74,500 t compared with 342,000 t in FY 2001.

Jindal Strips Ltd., a stainless steel and ferrochromium producer, planned to expand its annual stainless steel and ferrochromium production capacity. Jindal held 2.4 Mt chromite ore reserves in Orissa State and planned to build a 150,000-t/yr ferrochromium plant in Orissa using two Demag furnaces at a cost of about $35 million. Jindal also planned to build a 1-Mt/yr stainless steel plant in the Jaipur District, Orissa State, and a captive powerplant.

Tata Iron and Steel Company produced chromite ore, chromite concentrates, and ferrochromium. Tata increased its concentrator production capacity to 700,000 t/yr from 108,000 t/yr. The Government of India sets export quotas for lump chromite ore; however, there is no limitation on concentrates. Tata planned to build a 120,000-t/yr ferrochromium plant near Richards Bay, South Africa.

IMFA Group, comprising Indian Charge Chrome Ltd. (ICCL), an export-oriented producer, and Indian Metals and Ferroalloys (IMFA), a domestic-oriented producer, is integrated from chromite ore mining through ferrochromium production, including thermoelectric power generation. IMFA Group planned to restructure the company in order to move dollar debt to rupee debt. ICCL's dollar debt resulted in unexpected cost when the rupee-to-dollar exchange rate changed. IMFA reported chromite ore production in FY 2003 from its Nuashi and Sukinda Mines. Nuashi produced 60,000 t of lumpy chromite ore graded at 45% to 50% Cr_2O_3 from a proven reserve of 1.2 Mt. Nuashi planned to increase its production capacity to 90,000 t/yr by 2005. Sukinda produced 150,000 t of chromite ore from a proven reserve of 12 Mt. IMFA Group produced 102,539 t of ferrochromium, about 74,240 from ICCL and 28,299 t from IMFA in FY 2004, up from 100,368 t of ferrochromium, about 65,000 t from ICCL and 35,000 t from IMFA, in FY 2003. IMFA had a ferrochromium production capacity of 140,000 t/yr. IMFA planned to add two 24-megavoltampere (MVA) furnaces and one 48-MVA furnace by 2010 resulting in a 140,000 t/yr increase of ferrochromium production capacity. IMFA also planned to increase power production capacity and chromite ore production capacity to support the additional ferrochromium production capacity. IMFA planned a 120 megawatt powerplant and additional chromite ore production capacity of 400,000 t/yr.

Goyal reported Jindal's view of stainless steel for developing economies. Stainless steel accounted for 2% to 3% of world steel production. Growth of stainless steel production during the past 30 years was about 5.6%; however, from 2002 to 2003, production increased by 10.4% to 22.8 Mt from 20.7 Mt. Growth of carbon steel and aluminum was 1.7% and 3.4%, respectively, during the past 30 years. Global per capita stainless steel consumption was about 4 kilograms per person; however, excluding China and India, which together account for 37% of world population, it was 9 kilograms per person. In other words, per capita stainless steel consumption in China and India is small compared with that of the rest of the world, making the two countries a potential new market for stainless steel. By region in 2003, Asia accounted for 17.6% of stainless steel production; Central Europe and Eastern Europe, 9.9%; Western Europe and Africa, 4.9%; and the Americas, 3.7%. Goyal estimated 2003 world production distribution among grades to have been as follows: 200 series, 8%; 300 series, 68%, and 400 series, 24%. In India, 200 series accounted for 60% of stainless steel production. Consumption of 200 series in China grew by 22% from 2001 to 2003. Because India is a major producer of 200 series stainless steel and geographically near China, it is in a favorable position to supply that market. China was a net importer in 2003, consuming 4.2 Mt of stainless steel while producing only 1.8 Mt, and was expected to remain a net importer through 2008 or 2010 (Goyal, 2004).

Iran.—Iran produced 512,640 t of chromite ore in 2003 from proved reserves of 16.371 Mt (Industrial Minerals, 2004).

Italy.—Acciai Speciali Terni produced stainless steel at Terni, Umbria. Acciai is one of Europe's leading stainless steel producers with production capacity of 1.2 Mt/yr (Platts Metals Week, 2005).

Japan.—The Agency for Natural Resources and Energy was encouraged by the high price and short supply of ferrochromium to release ferrochromium from the Japanese national stockpile, which was started in 1983. As of March 31, Japan held about 68,596 t of ferrochromium in its stockpile (Metal-Pages, 2004e§).

In 2004, Japan imported 906,722 t of high-carbon ferrochromium, 221,278 t of chromite ore, 151,513 t of stainless steel scrap, 70,497 t of low-carbon ferrochromium, 4,098 t of chromium metal, and 1,117 t of ferrochromium silicon. Japan produced 3,774,895 t stainless and heat resisting steel (TEX Report, 2005a-b, f-h)

Higaki reported Nippon Steel & Sumikin Stainless Steel Corporation's (NSSC) view of the world stainless steel industry and characterized the Japanese stainless steel industry. Based on International Stainless Steel Forum statistics, Japan was the leading stainless steel-producing country with an 18% share of the 22.8 Mt of world stainless steel production in 2003 followed by the United States, the second ranked producer (10%). In 1993, world production was 10.9 Mt and Chinese stainless steel production was nil; however, in 2003, China was the world's fourth ranked world producer with a 1.8% share of world production, just after the Republic of Korea, which held a 2.0% share. NSSC accounted for 30% of Japanese production followed by Nisshin Steel Co., Ltd. and JFE Steel Corporation at 18% each, and Nippon Metal Industry Co., Ltd., and Nippon Yakin Kogyo Co., Ltd. at 10%. Ferritic stainless steel accounted for 39% of Japanese production, somewhat more than the world average, and was increasing. From the 4.1 Mt of stainless steel melted in 2003, Japan produced 3.7 Mt of products, 65% of which it consumed domestically and exported the remainder, primarily to China, the Republic of Korea, Hong Kong, and Taiwan. Domestic consumption was distributed among a variety of end uses. The largest end-use markets were machinery, with a 28% share, automotive (19%), home appliances (18%), and construction and civil engineering (18%). From September 2003 to September 2004, the prices of typical austenitic grade stainless steel rose by 47% while that of typical ferritic grade rose 17%, so NSSC planned to focus on helping customers substitute ferritic grades for austenitic grades and carbon steels, which NSSC also produces. Higaki estimated that the 4 Mt of stainless steel produced in Japan contained 700,000 t of chromium (200,000 t of nickel and 3.1 Mt of iron) of which 500,000 t came from 856,000 t of ferrochromium, and 200,000 t came equally from stainless steel and other nickel-containing scrap. Owing to the high cost of electricity ($0.05 to $0.06 per kilowatthour during the night and $0.15 per kilowatthour or more during the day) since 1993, Japanese ferrochromium plants have closed, leaving Japan virtually 100% import dependent for its ferrochromium needs (Higaki, 2004).

Kazakhstan.—Kazakhstan produced chromite ore, chromium chemicals and metal, and ferrochromium. Kazakhstan is the leading chromite ore and ferrochromium producing state of the Commonwealth of Independent States, has population of 15.3 million, and is situated in Asia between China and Russia. Kazakhastan produces significant quantities of several metals on a world scale. Gold, lead, and zinc production exceed 15% of world total, and chromium production exceeds 20% of world production. In addition to metals and minerals, Kazakhstan holds significant energy mineral resources. Kazakhstan's economy was growing at an annual rate of about 10%. Kazchrome, the world's second ranked ferrochromium producer, mined chromite ore through Donskoy GOK in Aqtobe Oblysy, produced high-, medium-, and low-carbon ferrochromium at the Aktyubinsk plant, Aqtobe Oblysy, and ferrochromium and ferrochromium-silicon at the Aksu plant, Pavlodar Oblysy. Donskoy GOK had a production capacity of 5 Mt/yr from a reserve of 350 Mt. Chromite ore production graded at 45% to 51% Cr_2O_3 with a chromium-to-iron ratio in the range of 3.5 to 4. Donskoy had a 700,000-t/yr pelletizing plant under construction that was expected to start operation in 2005. The Aktyubinsk plant started operation in 1943 and currently has a capacity of 265,000 t/yr from 16 furnaces. The Aksu plant started operation in 1967 and currently has a capacity of 750,000 t/yr from 26 furnaces. Aktyubinsk focuses on high-value, low-volume products, while Aksu focuses on high-volume, low-cost products. Both plants can change furnace products among grades and ferroalloys according to market conditions. Chromium materials accounted for about 80% of Kazchrome's 1.1 Mt of production; 786,000 t high-, 26,000 t medium-, and 32,000 t low-carbon ferrochromium; 42,000 t ferrochromium-silicon; and 1,200 t of chromium metal (Midgley, 2004).

Kazchrome planned to increase its 850,000-t/yr high-carbon ferrochromium production capacity 1.25 Mt/yr by constructing a pelletizing plant. Smelting pellets is more efficient than smelting fine ore, so the capacity increase will be achieved without the addition of furnaces. The pelletizing plant's production capacity was expected to be 700,000 t/yr.

Oriel Resources plc (United Kingdom) purchased the Voskhod chromite deposit, Khromtau, Aktubinsk Oblast, for $25 million from JSC Geoinvest [a subsidiary of Energinvest Holding Gmbh (Germany)]. Voskhod lies within the Kempirsayskiy Massif, a few kilometers (km) south of Donskoy GOK, the mining operation of Kazchrome. Voskhod is one large lens with nine smaller footwall protrusions at depths of 98 to 440 meters (m). The ore body is massive, high-grade, and 90 to 200 m thick. The Voskhod deposit was reported to contain 18.7 Mt of chromite ore at an average grade of 46.22% Cr_2O_3 (by JORC criteria). Out of this deposit, Oriel planned to develop a mine capable of producing 700,000 t/yr of chromite for 26 years, with China being the likely market. Oriel also planned to build a smelter comprising two 57-megawatt furnaces with production capacity of 240,000 t/yr of high-carbon ferrochromium grading 67% chromium at a cost of $266 million (London Stock Exchange, 2005).

Korea, Republic of.—The Republic of Korea produced stainless steel. In 2004, imports were reported to be 519,406 t of high carbon ferrochromium (compared with 462,440 t in 2003) and 57,149 t of low-carbon ferrochromium (compared with 24,290 t in 2003). The Republic of Korea also reported 2004 imports of 475,267 t of stainless steel scrap (compared with 344,868 t in 2003) (TEX Report, 2004a-b, j-k).

Moh reported Posco's view of the Republic of Korea's stainless steel industry. Changwon Specialty Steel and Posco produced crude stainless steel; Changwon produced long products; Posco produced flat products. From 1988 through 2003, Korean production of hot-rolled stainless steel rose to 1.55 Mt/yr from zero, an increase of 20.6% per year. Posco started stainless steel production in 1988 with one electric-arc furnace and added a second furnace in 1996 and a third in 2003. Type 300 stainless steel accounted for about 80% of Korean demand (Moh, 2004).

New Zealand.—New Zealand reported chromite occurrences; 6,000 t of chromite containing 20% to 54% Cr_2O_3 was mined in New Zealand between 1859 and 1902 (Christie, Brathwaite, and Johnson, 2004§). Small podiform chromite deposits occur along the length of the island. Fuchsite and uvarovite, other chromium-bearing minerals, have also been found.

Oman.—Oman Chromite Co. SAOG, established in 1991 to exploit Omani chromite deposits, reported production of metallurgical- and refractory-grade chromite ore near Sohar. Metallurgical grade ore had a chromium-to-iron ratio of 2.4; Cr_2O_3 content by weight of 39% to 41%; Al_2O_3, 15% to 17%; FeO, 14% to 16%; MgO, 17% to 19%; SiO less than 6%; and CaO less than 0.3%. Refractory grade ore had a Cr_2O_3 content by weight of more than 40%; Al_2O_3, more than 20%; FeO, 14% to 16%; MgO, 15% to 17%; SiO less than 3%; and CaO less than 0.2%.

Russia.—Russia produced chromite ore, chromium chemicals, ferroalloys, and metal. Russia exported 190,840 t of high-carbon ferrochromium in 2004 compared with 48,163 t in 2003, 2,170 t in 2002, and 14,645 t in 2001. Russia exported 161,631 t of low-carbon ferrochromium in 2004 compared with 149,003 t in 2003, 111,288 t in 2002, and 99,602 t in 2001. Russia exported 8,185 t of ferrochromium-silicon in 2004 compared with 3,844 t in 2003, 1,840 t in 2002, and none in 2001 (TEX Report, 2005i).

Chromium chemicals were produced at Russian Chrome 1915, Pervouralsk, Sverdlovsk Region, at the rate of about 30,000 t/yr. Russian Chrome was owned by the Kermas Group and Luigi Stoppani SpA (Italy). Kermas planned to sell its 50% share in Russian Chrome to Klyuchevsky Ferroalloy Plant, a chromium metal and ferrochromium producer (Metal-Pages, 2005a§-b§).

The Chelyabinsk Electrometallurgical Combine was in the process of expanding its operations. Chelyabinsk took over Kuznetsk Ferro-alloy Works, a ferrosilicon producer in Novokuznetsk. Chelyabinsk produced about 170,000 t of high-carbon ferrochromium and 130,000 t of low-carbon ferrochromium and planned to increase ferrochromium production to 300,000 t in 2005 and 450,000 t in 2006 by adding furnaces and an agglomeration plant. Chelyabinsk planned to develop its chromite ore resources at Tsentralnoye deposit in Yamalo-Nenets Autonomous District by adding an ore beneficiating plant and increasing mine production. The beneficiation plant had a planned production capacity of 700,000 t/yr at a cost of $2 million. The company planned to increase chromite production to 900,000 t/yr in 2005 and 1.4 Mt in 2006 from 700,000 t in 2004 (Ryan's Notes, 2004b; Metal-Pages, 2004b§-c§).

Kluchevsky Ferroalloy Plant reported production of chromium metal and ferrochromium. Kluchevsk produced about 10,500 t of chromium metal in 2004 and planned to increase production to 15,000 t in 2005 (Ryan's Notes, 2004f; Metal-Pages, 2004f§).

Tulachermet reported production of chromium metal by the electrolytic-process (Metal-Pages, 2004g§).

Serov Ferroalloy Plant reported production of low-carbon ferrochromium. Serov operated five low-carbon ferrochromium-producing furnaces with a collective production capacity of about 5,000 t/yr (Metal Bulletin, 2004b).

SZFK-Northwest Ferroalloys Company (owned about one-third by IST and two-thirds by IPH Polychrom Holding B.V.) started to build a ferrochromium plant at Tikhvin, Leningrad Region, about 200 km from Saint Petersburg. The plant's production capacity was planned to be 140,000 t/yr, comprised of four 16.5-MVA furnaces. Construction of the plant was expected to cost about $50 million and to be finished in 2005. SZFK planned to first smelter imported chromite ore, and then to switch over to chromite ore mined by the company's subsidiary Karelmet Joint Stock Company that planned to develop Agonozerskoye chromite deposit in Karelia Region (Ryan's Notes, 2004a, c).

South Africa.—In 2003, South Africa produced 7.405 Mt of chromite ore from which it produced 2.813 Mt of chromium ferroalloys (South Africa Minerals Bureau, unpub. data, March 15, 2005). South Africa exported 0.501 Mt of chromite ore and 2.640 Mt of ferrochromium (Kweyama, 2004). Based on chromite ore production and chromite ore and ferrochromium trade, South African chromium apparent consumption was 626,000 t of contained chromium. In 2004, 7,625,245 t of chromite ore was produced and 6,689,733 t was sold; domestic sales accounted for 92.5% of production (South Africa Minerals Bureau, unpub. data, March 15, 2005). Since 1994, South African chromite ore export sales as a fraction of production have decreased to less than one-tenth from about one-fourth, while chromite ore production has more than doubled.

Energy and transportation were issues facing the South African chromium industry. In the energy sector, peak shortages were expected by 2007 and base load shortages by 2011. Railroad and port facilities are required to move chromite ore and ferrochromium. While chromite ore exports were one-half of what they were 10 years before, ferrochromium exports had more than doubled. Development in the western belt of the Bushweld Complex means longer transportation from plants to ports.

Economic empowerment of blacks was another issue for the South African chromium industry in 2004. Black empowerment is relatively new in South Africa, so methods to make it work and the effects of doing it are unknown. Where some see success (because ownership by black-owned companies is increasing), others see failure (because only a few black-owned companies are participating) (Metal Bulletin, 2004a). The mining industry made significant progress at black economic empowerment. About 10% of gold and 8% of coal production had moved to the control of historically disadvantaged groups by yearend 2004. Black South Africans occupied about 12% of management positions from none when the historically disadvantaged group's empowerment law was passed. The successful empowerment of only a few black South Africans has caused some political leaders to question the effectiveness of black economic development, suggesting that more blacks should benefit from empowerment instead of the same blacks being reempowered. The Finance Minister delayed the application of royalties from the mining industry for 5 years while issues with the law are worked out. The major issue was that the Government proposed royalties on turnover instead of profits, the international standard. Other issues were differential royalty rates across mining sectors, and royalties paid to homelands (Chiaberta and Haase, 2004).

The ferrochromium industry had been growing at about 5% per year. That is equivalent to two to three new furnaces per year. National issues currently facing South Africa include environmental concerns over chromium emissions and dust generation, and adequacy of electrical power supply, shipping facilities, and transportation facilities.

The South African rand exchange rate went from R6.6 per dollar in January to R5.7 per dollar in December. This is the third year in a row that the exchange rate of the rand against the U.S. dollar decreased. For the same time period in 2003, it went from R8.6 per dollar to R6.5 per dollar and in 2002, from R11.5 per dollar to R8.9 per dollar (Pacific Exchange Rate, 2005§). The time-weighted 2004 annual average was R6.4453 per dollar.

Chromite ore became a byproduct of platinum mining a few years ago. Now platinum-group metals have become a byproduct of chromite mining. Tawana Projects (a joint venture between Bateman and ProPlant) began construction on a conventional flotation plant to recover platinum-group metal ore from chromite ore tailings from the Kroondal Mine (Botha, 2004).

International Ferrometals Ltd. (formerly Transvaal Ferroalloys) planned construction of a chromite mine and ferrochromium plant. The Buffelsfontein chromite deposit holds 24 Mt of chromite ore reserves to support production of 240,000 t/yr of ferrochromium. International Ferrometals completed an environmental impact assessment and an environmental management program report and received a mining permit, an environmental management plan, and started preengineering work. International Ferrometals and Jiuquan Iron & Steel (China) made a joint-venture agreement wherein Jiuquan took a 26% share and committed to take 120,000 t/yr of ferrochromium. International Ferrometals planned an initial public offering in 2005. International Ferrometals planned to build the plant near the mine, near Hartbeesport Dam, North West Province. Pyromet was contracted to build the plant comprising two 63-MVA closed furnaces with Outokumpu pelletizing technology at a cost of R1.1 billion ($170 million). Construction was estimated to take 16 months with an anticipated startup in 2005 (Isaacs, 2004).

ASA Metals (Pty.) Ltd. produced chromite ore and ferrochromium at Burgersfort, North West Province. ASA added a second, semiclosed 44-MVA furnace that raised production capacity to 120,000 t/yr from 70,000 t/yr at a cost of R144 million ($22 million). ASA is owned by East Asia Metal Investment (China) (60%) and Limpopo Development and Enterprises (40%) (Swindells, 2004).

Columbus Stainless produced stainless steel in Middelburg, Mpumalanga Province. Columbus completed expansion of their cold-rolling capacity to 400,000 t/yr at a cost of R1.1 billion ($170 million). Columbus is owned 64% by Acerinox SA and 12% each by Highveld Steel and Vanadium, the Industrial Development Corporation, and Samancor.

Before its closure in 1996, the Bathlako Mine produced 76,000 t/yr of chromite ore. EBCK Ltd. purchased the mine for about R40 million ($6.2 million). Bathlako is on the western edge of the Bushveld Complex, about 160 km northwest of Pretoria.

Assmang Limited reported ferrochromium production by financial year as follows: 295,000 t in 2004 (July 1, 2003, through June 30, 2004) and 244,000 t in 2003. Assmang's chromite ore production, in excess of that consumed in company operations, was 44,000 t in 2004 and 20,000 t in 2003. Feralloys Limited, owned by Assmang, produced chromite ore at Dwarsrivier and ferrochromium at Machadodorp. The Dwarsrivier Mine had a production capacity of 600,000 t/yr with plans to increase to 1 Mt/yr. Chromite operations (Dwarsrivier) increased reserves to 27.1 Mt from 25.9 Mt in 2003 and resources to 86.6 Mt from 69.8 Mt in 2003. Reserves and resources changed owing to the conversion of measured and indicated mineral resources to mineral reserves to compensate for the loss of production (Assmang, 2004§).

Tata Iron and Steel Co., Ltd. (India) planned to build a ferrochromium plant at Richards Bay, a port city removed from South Africa's chromite mines. Tata is a major chromite ore and ferrochromium producer in India. Tata planned to build a plant with production capacity of 120,000 t/yr with the potential to double it. Tata tested briquettes as an alternative to sintered pellets.

South African Chrome and Alloys Limited (SA Chrome) produced chromite ore and ferrochromium at Boshoek near Brits in North West Province. SA Chrome and Xstrata S.A. (Pty.) Ltd. formed a joint venture named Xstrata-SA Chrome. The joint venture has a ferrochromium production capacity of 1.45 Mt, which is equivalent to about one-fourth of world production, and is valued at R8.2 billion ($1.3 billion). SA Chrome took 11% of the joint venture, a share that grows to at least 17.5% by 2007. SA Chrome experienced startup problems for which it was not sufficiently funded. The joint venture provided access to funding, market access, and technical expertise. Xstrata had to meet the black empowerment investment share of 15% required under South Africa's new mining legislation. The share moves to 26% in 2009. SA Chrome reached its target production rate of 20,000 metric tons per month. SA Chrome also has the option to participate in Xstrata's Lion project (Lanham, 2004).

Hernic (Pty.) Ltd. produced chromite ore and ferrochromium at Brits, North West Province. Hernic continued to produce chromite ore from the Maroela Bult Mine while it developed shafts to access underground reserves of about 100 Mt evenly divided between the MG-1 and MG-2 seams. These seams are about 500 m underground. The company planned to begin underground mining in 2006. Hernic acquired mineral rights to nearby properties increasing their chromite ore reserves to about 240 Mt and started construction of a fourth furnace at its Brits plant. Hernic contracted Outokumpu (Finland) to install a 75-MVA, closed furnace with pelletizing, sintering, and preheating. The steel-belt sintering line would have a capacity of 360,000 t/yr. The new furnace was expected to come into operation in 2006, whereupon Hernic's ferrochromium production capacity would increase to 420,000 t/yr from 260,000 t/yr. The new furnace and associated equipment were expected to cost R450 million ($70 million). In addition, Hernic planned a new smelter about 10 km from Brits to have an initial ferrochromium production capacity of about 300,000 t/yr, with the potential to double that amount. Hernic is owned 51% by Mitsuishi Corporation (Japan), 25% by Industrial Development Corporation, 11.5% by ELG Haniel, 5% by International Finance Corporation, and 7.5% by management (Hernic (Pty.) Ltd., 2005§).

Xstrata produced 4.433 Mt of chromite ore in 2004 (72% of capacity) compared with 3.311 Mt in 2003. In 2004, Xstrata's chromite ore production by mine was as follows: Kroondal, 2.134 Mt; Thorncliffe, 1.487 Mt; Waterval, 0.405 Mt; Boshoek 0.253 Mt; Horizon, 0.131 Mt; and Chrome Eden, 0.023 Mt. Xstrata produced 1.488 Mt of ferrochromium in 2004 (92% of capacity) compared with 1.181 Mt in 2003. In 2004, Xstrata's ferrochromium production by plant was: Lydenburg, 393,000 t; Rustenburg, 393,000 t; Wonderkop, 311,000 t; Bosheok, 218,000 t; and Gemini, 173,000 t. Xstrata planned to increase ferrochromium production capacity by about 1 Mt/yr in three phases, 360,000 t/yr of which is in the first phase. The project was estimated to cost R1.67 million ($259,000). Xstrata planned to locate the new smelter at its Vantech facility in Mapumalanga Province. The new smelter would use new Xstrata-developed technology, which is more cost efficient than currently used technologies. Xstrata acquired African Carbon Group, a char producer in Mpumalanga Province. Char is a source of carbon for the production of ferrochromium (Xstrata, 2004§).

Samancor Chrome (owned 60% by BHP Billiton and 40% by Anglo American plc) operated chromite ore mines and ferrochromium smelters. Samancor's chromite ore production capacity was 3.5 Mt/yr, and ferrochromium, 1.1 Mt/yr. Samancor reported chromite ore resources of 519 Mt at an average grade of 42.8% Cr_2O_3 and reserves of 41.5 Mt at 37.6% Cr_2O_3. Samancor reported production of 1.026 Mt of ferrochromium in the 2004 financial year (July 1, 2002, through June 30, 2003) compared with 0.99 Mt in 2003 financial year. Anglo American and BHP announced plans to sell Samancor Chrome to the Kermas Group for $465 million by 2005. The sale comprised the Eastern Chrome and Western Chrome Mines and the Middelburg, Tubatse, and Witbank smelters; however, it excluded the Wonderkop and Palmiet plants. Issues associated with the sale include responsibility for environmental conditions, the status of mining leases, and black empowerment requirements. Samancor has three joint-venture agreements for the production of ferrochromium, Cromet, Middelburg Technochrome, and NST Ferrochrome. Cromet is a joint venture with Nippon Denko (Japan); Middelburg Technochrome, Showa Denko (Japan) and Marubeni (Japan); and NST Ferrochrome (Nippon Denko). Mogale Alloys leased the Palmiet plant where it processed stainless-steel dust generated by Columbus Stainless Steel. Mogale produced a master alloy containing 42% chromium and 2% nickel for use in stainless steel production. Mogale held enough dust in stock to produce the alloy for 3 years at a rate of 36,000 to 48,000 t/yr. Samancor and Xstrata operated a joint venture that produced ferrochromium at the Wonderkop plant. Samancor planned to increase ferrochromium production by adding furnaces at Witbank and Middelburg and by adding a pelletizing plant (Samancor, 2005§).

Taiwan.—Taiwan produced stainless steel. Taiwan reported imports of 417,050 t of high-carbon ferrochromium and 20,407 t of low-carbon ferrochromium in 2004 and 442,537 t of high-carbon ferrochromium and 15,914 t of low-carbon ferrochromium in 2003. Taiwan reported 2004 stainless-steel scrap imports of 334,060 t compared with 341,651 t in 2003 (TEX Report, 2005l-m).

Turkey.—Turkey produced chromite ore and ferrochromium. The Government of Turkey privatized Turkey's ferrochromium smelters—Eti Krom in Elazig Administrative Division, a high-carbon ferrochromium producer, and Eti Elektrometalurgji in Anatalya Administrative Division, a low-carbon ferrochromium producer. From a high-carbon ferrochromium production capacity of about 90,000 t/yr, Eti Krom reported production of 86,500 t in 2000, 41,480 t in 2001, 3,148 t in 2002, and 24,510 t in 2003 (Ryan's Notes, 2004e). Yildirim (a family-owned conglomerate) purchased Eti Krom for about $58 million. The purchase included Eti Krom's smelter and chromite mines containing chromite ore reserves of about 7 Mt and reserve base of about 10 Mt (Ryan's Notes, 2004g).

From a low-carbon ferrochromium production capacity of 11,500 t/yr and ferrochromium-silicon production capacity of 7,300 t/yr, Eti Elektrometalurgji reported low-carbon ferrochromium production of 9,255 t in 2001 and 11,200 t in 2002 and ferrochromium-silicon production of 5,895 t in 2001 and 7,245 t in 2002. Aksu Madencilik purchased Eti Elektrometalurgji for about $15.3 million (Ryan's Notes, 2004d).

Vietnam.—Vietnam produced chromite ore with a reported chromite ore grade of 38% to 39% Cr_2O_3 (Metal-Pages, 2004d§).

Zimbabwe.—Zimbabwe produced chromite ore and ferrochromium. Anglo American reported that Zimbabwe Alloys produced 31,000 t of ferrochromium in 2004 compared with 39,000 t in 2003. Zimbabwe Alloys reported that measured plus indicated chromite ore reserves dropped to 1.9 Mt at an average grade of 43.0% Cr_2O_3 in 2004 (0.7 Mt at 39.3% Cr_2O_3 measured plus 1.3 Mt at 44.9% Cr_2O_3 indicated) from 104.8 Mt at an average grade of 40.4% Cr_2O_3 in 2003 (0.6 Mt at 39.1% Cr_2O_3 measured plus 104.2 Mt at 40.4% Cr_2O_3 indicated) (Anglo American Corp., 2005§). Anglo American dropped 103 Mt of chromite ore appropriate for low-carbon ferrochromium production, a product that they no longer produce. Anglo American planned to sell Zimbabwe Alloys. Ferrochromium producers in Zimbabwe experienced problems because of the currency exchange rate.

Current Research and Technology

Mineral Processing and Industrial Applications.—Industry conducts research to develop new, more efficient processes and to improve the efficiency of currently used processes. The Council for Mineral Technology (Mintek) of South Africa conducts Government-sponsored, commercially sponsored and cosponsored research and development on chromite ore and ferrochromium.

Mintek.—Researchers at Mintek studied platinum-group-metal recovery from chromite tailings, electric-arc furnace processing of stainless-steel dust, and the chromium-platinum phase diagram. Mintek demonstrated a flotation procedure at the laboratory scale that separates platinum-group metals from chromite tailings. Mintek worked on a feasibility study for the production of 20,000 ounces per year (600 kilograms per year) of platinum from one chromite operation.

Mintek participated in Mogale Alloys through its subsidiary Mindev. Mogale commissioned a stainless-steel dust agglomeration plant and started smelting a combination of chromite ore and stainless-steel dust in its 40-MVA furnace at Samancor's Palmiet Ferrochrome Plant. Mogale gets stainless-steel dust from the Columbus Stainless Plant, which takes back part of the Mogale's chromium-nickel-containing alloy production. Mogales ferrochromium production capacity was about 40,000 t/yr.

Mintek studied direct current (DC) arc furnace ferrochromium production using chromite ore in a fluidized bed flash preheater. Preheating the chromite feed materials resulted in a 20% energy savings. Mintek studied the metallurgical characteristics, such as tensile strength, creep, and phase diagrams, of chromium-containing platinum-base alloys (platinum-aluminum-chromum and platinum-chromium-ruthenium) that could replace nickel-base superalloys. Mintek also studied the possibility of increasing the 50-MVA limit in DC smelting imposed by the current-carrying capacity of one electrode through the development of a two-cathode furnace with each cathode independently powered (Mintek, 2004§).

Research.—Feng and Aldrich (2004) studied the recovery of chromite fines from wastewater streams. South Africa's Western Chrome Mine experienced resource loss and water contamination when wastewater containing 3% chromite of less than 100-micrometer size reported to the tailings pond. The authors found that they could recover as much as 95.6% of the chromite; however, recovery deteriorated as the chromite aged.

Yildiz and Sengil (2004) produced sodium chromate from chromite using an alkali-fusion process, which determined the efficient conditions for alkali fusing and leach operations. The authors achieved a chromium recovery of 96.2% on chromite of Turkish origin containing 36.23% chromium when processed at 650° C for 60 minutes with a sodium hydroxide-to-Cr_2O_3 weight ratio of 6 to 1.

Tathavadkar and others (2004) investigated the mineralogical properties of chemical-grade chromite ore from five geographical areas to improve extraction efficiency of sodium dichromate production using the soda ash roasting process. The authors found that chemical-grade chromite ore (defined as 40% to 46% Cr_2O_3) was inadequate to describe the ores alkali roasting behavior. Chemical-grade chromite ore showed a wide range of chemical compositions, chromite mineral structure, and alteration properties. The authors observed that South African chromite ore was predominantly chromite mineral, while that of Indian origin was magnesiochromite mineral.

The Department of Defense (DOD) developed a trivalent chromium pre- and post-treatment (TCP) for aluminum and zinc products. TCP is the only nonhexavalent chromium coating that meets military specification for aluminum (Advanced Materials and Processes, 2004). The Department of Energy (DOE) developed a chromium-containing steel alloy that can be cast into large structures (rods as large as 12 millimeters) yet retain an amorphous structure. The amorphous structure results in engineering properties better than those of traditional alloys, yet at a cost substantially less than currently available amorphous alloys (Lu and others, 2004).

Researchers studied the amount of chromium released from stainless-steel products used in outdoor applications (such as roofs). The study was conducted to address increasing societal concerns about such environmental releases. The study comprised field and laboratory exposure of Types 304 and 316 stainless steel, and the percolation of runoff water from those steels in soil. The authors found that the amount of chromium released from Type 304 ranged from 0.2 to 0.6 milligrams per square meter (mg/m^2), while that from Type 316 released ranged from 0.2 to 0.7 mg/m^2. The authors also found that the chromium in runoff water was predominantly (98.5%) in the trivalent state and that soils tested had a high-retention capacity (98%) (Berggren and others, 2004).

Chromium in the earth's magma has been identified as potentially having a role in hydrocarbon formation and earthquake detection. In laboratory conditions that simulated the magma-ocean interface, chromium was found to accelerate the formation of hydrocarbons from hydrogen gas and carbon dioxide (University of Minnesota, 2005§). Skelton (2005§) found that the chromium concentration of water from a depth of 1.5 km increased significantly before an earthquake.

Technology.—The USGS developed a new cation-exchange method for the field speciation of hexavalent chromium. Chromium is usually present in surface and ground water in either the trivalent or hexavalent oxidation state. Because trivalent chromium is considered an essential nutrient and hexavalent chromium is considered a toxin and a carcinogen, it is importation to distinguish between oxidation states of chromium. The new method uses disposable syringes and cation-exchange cartridges to preserve samples in concentrated hydrochloric acid for later laboratory analysis (U.S. Geological Survey, 2003).

Snyder (2003) reported that trivalent chromium plating has been replacing hexavalent chromium plating since 1975 and that, while hexavalent processes were prevalent, trivalent processes were likely to become a larger portion of that industry.

Tsomondo and Simbi (2002) studied the kinetics of chromite ore reduction to produce high-carbon ferrochromium to optimize chromium recovery in the smelting process. Chromite reduction showed a fast period followed by a slow period. The fast period occurred when Cr_2O_3 was converted to CrO in the slag, a diffusion-limited process. The slow period was characterized as thermodynamically controlled.

Environment.—Klee and Graedel (2004) applied their model of elemental anthropogenic and natural mobilization to chromium. Applying that model with 5,300 Mt of chromium from mining in 2004 yields a total chromium mobilization of 5,510 Mt; a ratio of anthropogenic to natural mobilization of 51; and anthropogenic as a percentage of total of 98%. Chromium mobilization is dominated by anthropogenic activity.

Outlook

The outlook for chromium consumption in the United States and the rest of the world is about the same as that for stainless steel, which is the major end use for chromium worldwide. Thus, stainless steel industry performance largely determines chromium industry demand worldwide.

The trend to supply chromium in the form of ferrochromium by countries that mine chromite ore is expected to continue. The rising cost of ferrochromium sustained independent ferrochromium producers; however, other factors being equal, ferrochromium production is most cost effective when the ferrochromium plant is close to the chromite mine. With new efficient, reliable ferrochromium production facilities in chromite-ore-producing countries, ferrochromium capacity and production are expected to diminish in countries that produce ferrochromium but not the chromite ore. Further vertical integration of the chromium industry is expected as chromite-ore-producing countries expand ferrochromium or stainless steel production capacity.

References Cited

Advanced Materials and Processes, 2004, Trivalent chromium pretreatment protects aluminum and zinc: Advanced Materials & Processes, v. 162, no. 11, November, p. 22.

Berggren, D., Bertling, S., Heijerick, D., Herting, G., Koundakjian, P., Leygraf, C., and Wallinder, I.O., 2004, Release of chromium, nickel and iron from stainless steel exposed under atmospheric conditions and the environmental interaction of these metals: Brussels, Belgium, European Confederation of Iron and Steel Industries, October, 53 p.

Bi, Junsheng, 2004, Persisting in a scientific approach to development promoting the sustainable development of China's chromium chemical industry: International Chromium Development Association Meeting Chromium 2004, Shanghai, China, October 12-15, 2004, Presentation, [unpaginated].

Botha, Zonika, 2004, Main contract awarded at chromite-to-PGMs treatment project: Mining Weekly, March 26-April 1, p. 33.

Boyle, E.H., Jr., Shields, D.J., and Wagner, L.A., 1993, Chromium availability in market economy countries and network flow model analysis of world chromium supply: U.S. Bureau of Mines Information Circular 9337, 83 p.

Campbell, Chris, 2004, Opening address: International Chromium Development Association Meeting Chromium 2004, Shanghai, China, October 12-15, 2004, Presentation, [unpaginated].

Chiaberta, Steven, and Haase, Candice, 2004, Tax consultations are to continue: Mining Weekly, February 27-March 4, p. 5.

Consolidated Minerals Limited, 2004, Annual report 2004: West Perth, Australia, Consolidated Minerals Limited, Australia, 72 p.

Defense National Stockpile Center, 2004, Annual materials plan for FY 2004 revised: Defense National Stockpile Center News Release DNSC-04-2471, May 4, 2 p.

Defense National Stockpile Center, 2005, Annual materials plan for FY 2005: Defense National Stockpile Center News Release DNSC-05-2649, August 17, 2 p.

DeYoung, J.H., Jr., Lee, M.P., and Lipin, B.R., 1984, International Strategic Minerals Inventory summary report—Chromium: U.S. Geological Survey Circular 930-B, 41 p.

Durrant, Angela, 2005, The role of China as a producer and consumer of steel and ferroalloys: Platts Steel and Ferroalloys Conference, Pittsburgh, PA, June 14, Presentation, [unpaginated].

European Union, 2003, Directive 1002/95/EC of the European Parliament and the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment: Official Journal of the European Union, February 13, p. L 37/19-33.

Feng, D., and Aldrich, C., 2004, Recovery of chromite fines from wastewater streams by column flotation: Hydrometallurgy, v. 72, p. 319-325.

Gilet, Jean-Yves, 2004, ARCELOR stainless steel sector: International Chromium Development Association Meeting Chromium 2004, Shanghai, China, October 12-14, 2004, Presentation, [unpaginated].

Goyal, R.K., 2004, Stainless steel for developing countries: International Chromium Development Association Meeting Chromium 2004, Shanghai, China, October 12-14, 2004, Presentation, [unpaginated].

Higaki, H., 2004, The Japanese stainless steel industry and its strategy: International Chromium Development Association Meeting Chromium 2004, Shanghai, China, October 12-14, 2004, Presentation, [unpaginated].

Industrial Minerals, 2004, Refractory minerals of Iran—Seeking domestic supply alternatives to imports, Chromite: Industrial Minerals, no. 442, July, p. 48.

International Chromium Development Association, 2005, ICDA statistical bulletin 2005 edition: Paris, France, Chromium Development Association, July, 45 p.

Isaacs, Zeena, 2004, Furnace, kilns, ovens & dryers: Mining Weekly, May 14-20, p. 21-22.

Klee, R.J., and Graedel, T.E., 2004, Elemental cycles, *in* A status report on human or natural dominance: Annual Review of Environment and Resources, v. 29, p. 69-107.

Kweyama, N., 2004, Chromium, *in* South Africa's minerals industry 2003/2004 (21st ed.): Pretoria, South Africa, Department of Minerals and Energy, December, p. 124-128.
Lanham, Andrew, 2004, SA chrome expects a lower-cost future: Mining Weekly, October 28.
Li, Cheng, 2004, A survey of recent developments of stainless steel in China: International Chromium Development Association Meeting Chromium 2004, Shanghai, China, October 12-15, 2004, Presentation, [unpaginated].
Li, Shirong, 2004, Summary of the speech given at the ICDA conference in Shanghai by the Erdos People's Government Deputy Mayor Li Shirong of Inner Mongolia Autonomous: International Chromium Development Association Meeting Chromium 2004, Shanghai, China, October 12-15, 2004, Presentation, [unpaginated].
London Stock Exchange, 2005, Purchase agreement signed in relation to the Voskhod chrome deposit: London, United Kingdom, London Stock Exchange RNS No. 5328H, January 19, 2 p.
Lu, Z.P., Liu, C.T., Thompson, J.R., and Porter, W.D., 2004, Structural amorphous steels: Physical Review Letters, v. 92, no. 24, p. 245503-1-245503-4.
Metal Bulletin, 2004a, New black mining elite in the firing line: Metal Bulletin, no. 8865, October 25, p. 12-13.
Metal Bulletin, 2004b, Serov using just four low-carbon ferro-chrome furnaces: Metal Bulletin, no. 8862, October 12, p. 12.
Midgley, Mark, 2004, Kazchrome and the Ferro Chrome Industry: Metal Bulletin Conference, Barcelona, Spain, November 8, 2004, Presentation, [unpaginated].
Moh, Jin-Tae, 2004, The Korean approach to stainless steel production: International Chromium Development Association Meeting Chromium 2004, Shanghai, China, October 12-14, 2004, Presentation, [unpaginated].
Platts Metals Week, 2004, China's stainless demand growth slows, trend to continue: Platts Metals Week, v. 75, no. 21, May 24, p. 5-6.
Platts Metals Week, 2005, Arcelor stainless output down in 2004: Platts Metals Week, v. 76, no. 8, February 21, p. 8.
Riekkola-Vanhanen, Masrja, 1999, The Finnish environment 314—Finnish expert report on best available techniques in ferrochromium production: Helsinki, Finland, Finnish Environment Institute, June, 49 p.
Ryan's Notes, 2004a, A new Russian FeCr producer: Ryan's Notes, v. 10, no. 26, June 28, p. 3.
Ryan's Notes, 2004b, Chelyabinsk to take a leading role in FeCr: Ryan's Notes, v. 10, no. 44, November 1, p. 2-3.
Ryan's Notes, 2004c, DLA nears end of FeCr FY2004 sales: Ryan's Notes, v. 10, no. 31, August 2, p. 5.
Ryan's Notes, 2004d, Eti Elektrometalurgji finds a buyer: Ryan's Notes, v. 10, no. 34, August 23, p. 1.
Ryan's Notes, 2004e, Eti Krom sold to local Turkish company: Ryan's Notes, v. 10, no. 19, May 10, p. 1.
Ryan's Notes, 2004f, HC ferrochrome prices advance: Ryan's Notes, v. 10, no. 50, December 13, p. 3.
Ryan's Notes, 2004g, Yildirm, the new power in FeCr: Ryan's Notes, v. 10, no. 38, September 20, p. 2.
Snyder, D.L., 2003, Decorative chromium plating: Metal Finishing, v. 101, no. 1A, p. 170-177.
Swindells, Steve, 2004, ASA Metals boosts ferro-chrome capacity: Metal Bulletin, no. 8827, February 2, p. 17.
Tathavadkar, V.D., Antony, M.P., and Jha, A., 2004, An investigation of the mineralogical properties of chemical grade chromite minerals: Scandinavian Journal of Metallurgy, v. 33, no. 2, p. 65-75.
TEX Report, 2004a, South Korea's imports of main ferro-alloys in CY 2003: TEX Report, v. 36, no. 8511, April 28, p. 7.
TEX Report, 2004b, Yard to export stainless steel scrap for S. Korea is constructed in Kawasaki: TEX Report, v. 36, no. 8557, July 7, p. 4.
TEX Report, 2005a, (Custom statistics) Japan's imports of rare-metals in December 2004: TEX Report, v. 37, no. 8691, February 1, p. 10.
TEX Report, 2005b, (Custom statistics) Japan's imports of raw materials ores (for ferro-alloys production) in December 2004: TEX Report, v. 37, no. 8691, February 1, p. 9.
TEX Report, 2005c, China's exports of ferro-alloys in 2004 reached 2,180,000 tons exceeding level of 2 million: TEX Report, v. 37, no. 8698, February 10, p. 4.
TEX Report, 2005d, China's imports of chrome ore in CY 2004: TEX Report, v. 37, no. 8701, February 16, p. 6.
TEX Report, 2005e, Exports and imports of ferro-chrome by China in December 2004: TEX Report, v. 37, no. 8703, February 18, p. 4.
TEX Report, 2005f, Imports of ferro-alloys into Japan in CY 2004 indicated higher prices as actually risen: TEX Report, v. 37, no. 8690, January 31, p. 3.
TEX Report, 2005g, Imports of stainless steel scrap by four countries in Asia: TEX Report, v. 37, no. 8779, June 14, p. 6.
TEX Report, 2005h, Output of stainless steel products in Japan for CY 2004: TEX Report, v. 37, no. 8701, February 16, p. 8.
TEX Report, 2005i, Russia's exports of ferro-alloys in Jan.-Dec. 2004: TEX Report, v. 37, no. 8763, May 23, p. 6.
TEX Report, 2005j, South Korea's imports of main ferro-alloys in CY 2004: TEX Report, v. 37, no. 8763, May 23, p. 6.
TEX Report, 2005k, South Korea's imports of stainless steel scrap in January 2005: TEX Report, v. 37, no. 8779, June 14, p. 9.
TEX Report, 2005l, Taiwan's imports of ferroalloys in January 2005: TEX Report, v. 37, no. 8767, May 27, p. 8.
TEX Report, 2005m, Taiwan's imports of stainless steel scrap in January 2005: TEX Report, v. 37, no. 8768, May 30, p. 7.
Tsomondo, M.B.C., and Simbi, D.J., 2002, Kinetics of chromite ore reduction from MgO-CaO-SiO_2-FeO-Cr_2O_3-Al_2O_3 slag system by carbon dissolved in high carbon ferrochromium alloy bath: Ironmaking and Steelmaking, v. 29, no. 1, p. 22-28.
U.S. Geological Survey, 2003, New cation-exchange method for field speciation of hexavalent chromium: U.S. Geological Survey Fact Sheet FS-006-03, August, 4 p.
Yildiz, Kenan, and Sengil, I.A., 2004, Investigation of efficient conditions for chromate production from chromite concentrate by alkali fusion: Scandinavian Journal of Metallurgy, v. 33, no. 4, p. 251-256.
Zhang, Ronghai, 2004, Stainless steel business & FeCr demand within Baosteel: International Chromium Development Association Meeting Chromium 2004, Shanghai, China, October 12-15, 2004, Presentation, [unpaginated].
Zheng, Yuan Hua, 2004, Outlook on production and demand of Chinese ferrochrome industry: International Chromium Development Association Meeting Chromium 2004, Shanghai, China, October 12-15, 2004, Presentation, [unpaginated].

Internet References Cited

Anglo American Corp., 2005, Meeting the world's needs—Annual report 2004, accessed July 2005, via URL http://www.angloamerican.co.uk.
Assmang, 2004, Annual report 2004, accessed April 15, 2005, via URL http://www.assmang.co.za.
Christie, Tony, Brathwaite, Bob, and Johnson, Mike, 2004, Mineral Commodity Report 3— Chromium, accessed April 22, 2005, at URL http://crownminerals.med.govt.nz/minerals/docs/comreports/report03_chromium.pdf.
Ferbasa, 2005, Cia de Ferro Ligas da Bahia—Ferbasa e suas controladas, accessed May 5, 2005, at URL http://www.ferbasanet.com.br/balan_2004.pdf.
Gonçalves, Maria de Melo, 2004, Cromo, *in* Sumário mineral [Mineral summaries] 2003, accessed May 7, 2005, via URL http://www.dnpm.gov.br.
Government of Western Australia, 2005, Western Australian mineral and petroleum statistics digest 2003-04, accessed September 13, 2005, at URL http://www.doir.wa.gov.au/documents/mineralsandpetroleum/statsdigest04.pdf.
Hernic (Pty.) Ltd., 2005, various pages, accessed August 2005 via URL http://www.hernic.co.za.
Indian Bureau of Mines, 2004, Mineral information—Mineral production, accessed June 21, 2005, via URL http://ibm.nic.in.
International Stainless Steel Forum, 2005, Stainless steel production—Stainless and heat resisting steel production (ingot/slab equivalent), accessed July 13, 2005, via URL http://www.worldstainless.org/statistics.php.
Metal-Pages, 2004a, Albania investment boost, accessed October 18, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004b, Chelyabinsk construction under way, accessed June 8, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004c, Chelyabinsk plans major expansion, accessed November 4, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004d, FeCr plunge on quiet market, accessed June 30, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004e, Japan plans more tenders, accessed May 12, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004f, Klyuchevsky to treble profits, accessed May 6, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004g, Tulachermet expands, accessed May 10, 2004, via URL http://www.metal-pages.com.

Metal-Pages, 2005a, Russian Chrome sale agreed, accessed March 15, 2005, via URL http://www.metal-pages.com.
Metal-Pages, 2005b, Russian Chrome stake up for sale, accessed February 25, 2005, via URL http://www.metal-pages.com.
Mintek, 2004, Annual report 2004, accessed August 2005, via URL http://www.mintek.ac.za.
Natural Resources Canada, 2005, Statistical report, Canadian Minerals Yearbook 2003, accessed 2005 via URL http://www.nrcan.gc.ca/mms/cmy/content/2003/69.pdf.
Outokumpu, 2005, Annual report 2004, accessed June 2005, via URL http://www.outokumpu.com.
Pacific Exchange Rate Service, 2005, Database retrieval system (v2.11), accessed April 13, 2005, via URL http://fx.sauder.ubc.ca/data.html.
Samancor, 2005, various pages, accessed August 2005, via URL http://www.samancor.co.za.
Skelton, Alasdair, 2005, Hydrogeochemical changes might predict major earthquakes, Stockholm University, accessed August 25, 2005, at URL http://www.sweden.se/templates/cs/News____9607.aspx.
University of Minnesota, 2005, A deep sea hydrocarbon factory, accessed August 25, 2005, at URL http://www.ur.umn.edu/FMPro?-db=releases&-lay=web&-format=umnnewsreleases/releasesdetail.html&ID=2000&-Find.
Xstrata plc, 2004, Annual report 2004, accessed April 2004, via URL http://www.xstrata.com.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Chromium. Ch. in Mineral Commodity Summaries, annual.
Chromium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Chromium. International Strategic Minerals Inventory Summary Report, Circular 930-B, 1984.
Chromium. Mineral Industry Surveys, monthly.

Other

American Iron and Steel Institute.
Chromite. Ch. in Industrial Minerals and Rocks (6th ed.), Society for Mining, Metallurgy, and Exploration, Inc., Carr, D.D., ed., 1994.
Chromium. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
Economics of Chromium, The. Roskill Information Services, Ltd.
International Chromium Development Association.
South Africa's Minerals Industry. South Africa Minerals Bureau.
Strategic and Critical Materials Report to the Congress. U.S. Department of Defense.

TABLE 1
SALIENT CHROMIUM STATISTICS[1]

		2000	2001	2002	2003	2004
World, production, contained chromium:						
Chromite ore (mine)[2]	metric tons	4,430,000 [r]	3,650,000	4,290,000	4,660,000 [r]	5,260,000 [e]
Ferrochromium (smelter)[3]	do.	3,280,000 [r]	2,670,000 [r]	2,860,000 [r]	3,460,000 [r]	3,790,000 [e]
Stainless steel[4]	do.	3,560,000 [r]	3,170,000 [r]	3,410,000 [r]	3,760,000 [r]	4,060,000 [e]
U.S. supply:						
Components of U.S. supply, contained chromium:						
Domestic mines	do.	--	--	--	--	--
Secondary	do.	161,000 [r]	141,000 [r]	174,000 [r]	180,000 [r]	168,000
Imports:						
Chromite ore	do.	86,200	62,000	35,300	55,300	49,500
Chromium chemicals	do.	12,600 [r]	12,800	17,400	10,300	6,040
Chromium ferroalloys	do.	344,000	156,000	203,000	243,000	261,000
Chromium metal	do.	9,930	8,190	7,430	8,570	9,630
Stocks, January 1:						
Government	do.	909,000	825,000 [e, 5]	706,000	643,000 [r]	560,000
Industry[6]	do.	14,600	14,400 [r]	16,700	8,390 [r]	9,870
Total	do.	1,540,000 [r]	1,220,000 [r]	1,160,000 [r]	1,150,000 [r]	1,060,000
Distribution of U.S. supply, contained chromium:						
Exports:						
Chromite ore	do.	44,600	20,000	7,680	32,800	14,000
Chromium chemicals	do.	16,400	13,200	10,500	9,710	14,500
Chromium ferroalloys and metal	do.	25,400	9,840	10,800	3,770	6,250
Stocks, December 31:						
Government	do.	825,000	816,000 [e, 5]	643,000 [r]	560,000 [r]	466,000
Industry[6]	do.	14,400 [r]	16,700	8,390 [r]	9,870 [r]	7,890
Total	do.	925,000 [r]	875,000	681,000 [r]	616,000 [r]	508,000
Production, reported:[7]						
Chromium ferroalloy and metal net production:						
Gross weight	do.	W	W	W	W	W
Chromium content	do.	W	W	W	W	W
Net shipments, contained chromium	do.	W	W	W	W	W
Consumption:						
Apparent, contained chromium	do.	612,000 [r]	344,000 [r]	479,000 [r]	532,000 [r]	555,000
Reported:						
Chromite ore and concentrates, gross weight	do.	W	W	W	W	W
Chromite ore, average Cr_2O_3	percent	44.8	45.0	45.4	45.0	45.0
Chromium ferroalloys:[8]						
Gross weight	metric tons	441,000 [r]	351,000 [r]	407,000 [r]	411,000 [r]	449,000
Contained chromium	do.	231,000 [r]	202,000 [r]	236,000 [r]	240,000 [r]	262,000
Chromium metal, gross weight	do.	4,990	5,890	5,080	5,140	5,690
Stocks, December 31, gross weight:						
Government:						
Chromite ore	do.	636,000	636,000 [e, 5]	339,000 [r]	235,000 [r]	135,000
Chromium ferroalloys	do.	919,000	906,000 [e, 5]	767,000 [r]	691,000 [r]	595,000
Chromium metal	do.	7,550	7,430 [e, 5]	7,220	7,120 [r]	6,670
Industry:		W	W	W	W	W
Producer[9]	do.					
Consumer:						
Chromite ore[10]	do.	W	W	W	W	W
Chromium ferroalloys[11]	do.	26,300 [r]	28,100	13,800 [r]	16,300 [r]	13,100
Chromium metal	do.	191	210	230	242	182
Prices, average annual:						
Ferrochromium, chromium content[13]	dollars per pound	$0.414	$0.324	$0.317	$0.433	$0.689
Standard chromium metal, gross weight[14]	do.	$4.43	$4.24	NA	NA	NA
Vacuum chromium metal, gross weight[14]	do.	$5.42	$5.43	NA	NA	NA
Electrolytic chromium metal, gross weight[15]	do.	$4.50	$4.50	$4.50	$4.50	$4.50
Aluminothermic chromium metal, gross weight[16]	do.	$2.35	$2.08	$2.08	$1.84	$2.27

See footnotes at end of table.

TABLE 1—Continued

SALIENT CHROMIUM STATISTICS[1]

		2000	2001	2002	2003	2004
U.S. supply—Continued:						
Consumption—Continued:						
Value of trade:[17]						
Exports, contained chromium	thousands	$110,000	$89,400	$67,600	$58,400	$80,700
Imports, contained chromium	do.	$427,000	$239,000	$256,000	$322,000	$477,000
Net exports, contained chromium[18]	do.	-$317,000	-$149,000	-$188,000	-$264,000	-$397,000
Stainless steel:						
Production:[19]						
Gross weight	metric tons	2,190,000	1,820,000	2,190,000	2,220,000	2,400,000
Contained chromium[20]	do.	357,000	296,000	369,000	373,000	407,000
Average grade, dimensionless[21]		0.1625	0.1629	0.1688	0.1683	0.1696
Shipments, gross weight[20]	metric tons	1,930,000	1,670,000	1,720,000	1,790,000 r	1,880,000
Exports, gross weight	do.	264,000	249,000	273,000	327,000	323,000
Imports, gross weight	do.	989,000	761,000	752,000	639,000	811,000
Scrap, gross weight:						
Receipts	do.	945,000 r	832,000 r	1,020,000 r	1,060,000 r	987,000
Consumption	do.	1,380,000 r	1,220,000 r	1,380,000 r	1,430,000 r	1,410,000
Exports	do.	468,000	438,000	342,000	505,000	478,000
Imports	do.	56,200	42,300	81,000	89,200	146,000
Value of trade, gross weight:						
Exports	thousands	$782,000	$752,000	$742,000	$895,000	$1,030,000
Imports	do.	$2,010,000	$1,430,000	$1,350,000	$1,320,000	$2,230,000
Scrap exports	do.	$310,000	$270,000	$252,000	$382,000	$548,000
Scrap imports	do.	$35,500	$24,100	$49,400	$70,200	$160,000
Net exports[18, 22]	do.	-$955,000	-$433,000	-$405,000	-$115,000	-$809,000

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Calculated assuming chromite ore to average 44% Cr_2O_3, which is 68.42% chromium.

[3]Calculated assuming chromium content of ferrochromium to average 57%.

[4]Calculated assuming chromium content of stainless steel to average 17%.

[5]2001 stocks were estimated based on the previous accounting system and reported sales. Stocks before and after 2001 are those reported by the National Defense Stockpile.

[6]Includes consumer stocks of chromium ferroalloys and metal and other chromium-containing materials.

[7]Includes chromium ferroalloys and metal and other chromium materials in the United States.

[8]Chromium ferroalloy, chromite ore, and other chromium-containing materials excluding chromium metal.

[9]Chromium ferroalloy and metal producer stocks of chromium ferroalloys and metal.

[10]Chemical, chromium ferroalloy and metal, and refractory producer stocks of chromite ore.

[11]Consumer stocks of chromium ferroalloys, chromite ore, and other chromium-containing materials excluding chromium metal.

[12]Time-weighted average U.S. price of South African chromite ore, as reported in Platts Metals Week.

[13]Time-weighted average U.S. price of imported high-carbon chromium that contains 50% to 55% chromium, as reported in Platts Metals Week.

[14]Time-weighted average U.S. price of electrolytic chromium metal, as reported in American Metal Market, before 2002.

[15]Time-weighted average U.S. price of domestically produced electrolytic chromium metal as reported by Ryan's Notes.

[16]Time-weighted average U.S. price of imported aluminothermic chromium metal as reported by Ryan's Notes.

[17]Includes chromite ore and chromium ferroalloys, metal, and chemicals.

[18]Data indicate that imports are greater than exports.

[19]Source: American Iron and Steel Institute Annual Reports and quarterly reports of stainless and heat-resisting raw steel production and shipments.

[20]Estimated mass-weighted average of the mean chromium (Cr) content of stainless steel production by grade. Uncertainty is approximatly$\pm$ 0.01 owing to the range of chromium chemical specification limits by stainless steel grade.

[21]Ratio of estimated mass-weighted average Cr content of stainless steel production by grade to production. Expressed as a fraction.

[22]Includes stainless steel and stainless steel scrap.

TABLE 2

U.S. REPORTED CONSUMPTION AND STOCKS OF CHROMIUM PRODUCTS[1]

(Metric tons)

	2003		2004		Change[2]	
	Gross weight	Chromium content	Gross weight	Chromium content	Quantity	Percentage
Consumption by end use:						
Alloy uses:						
Iron alloys:						
Steel:						
Carbon steel	5,140 r	3,010 r	6,510	3,920	1,370	27
High-strength low-alloy steel	7,280	4,040	7,970	4,410	687	9
Stainless and heat-resisting steel	346,000 r	202,000 r	375,000	219,000	28,900	8
Full alloy steel	18,400 r	11,200 r	20,300	12,200	1,880	10
Tool steel	5,840	3,480	5,920	3,580	87	1
Superalloys	8,270 r	6,770 r	14,000	10,700	5,750	70
Other alloys[3]	22,300	12,700	21,700	12,400	-640	-3
Other uses not reported above	3,010	1,800	3,230	2,000	219	7
Total	416,000 r	245,000 r	454,000	268,000	38,300	9
Consumption by material:						
Low-carbon ferrochromium	34,700 r	23,300 r	37,000	25,100	2,330	7
High-carbon ferrochromium	333,000 r	200,000 r	372,000	222,000	38,700	12
Ferrochromium silicon	39,000	15,200	35,700	13,800	-3,320	-9
Chromium metal	5,140	5,130	5,690	5,690	555	11
Chromite ore	2,660	834	2,670	840	7	--
Chromium-aluminum alloy	632	355	617	420	-15	-2
Other chromium materials	494	235	507	295	13	3
Total	416,000 r	245,000 r	454,000	268,000	38,300	9
Consumer stocks:						
Low-carbon ferrochromium	1,810 r	1,220 r	2,110	1,430	301	17
High-carbon ferrochromium	13,100	7,820 r	9,560	5,690	-3,490	-27
Ferrochromium silicon	1,250	484	1,190	461	-56	-4
Chromium metal	242	242	182	182	-60	-25
Chromite ore	80	25	78	25	-2	-3
Chromium-aluminum alloy	84	47	89	61	5	6
Other chromium materials	73	34	64	37	-9	-12
Total	16,600 r	9,870 r	13,300	7,890	-3,310	-20
National Defense Stockpile stocks:[4]						
Chromite ore:[5]						
Chemical[6]	78,800	22,500	46,300	13,300	-32,500	-41
Refractory[7]	156,000	37,300	88,300	21,100	-67,700	-43
Chromium ferroalloys:[8]						
High-carbon ferrochromium[9]	473,000	337,000	398,000	284,000	-74,900	-16
Low-carbon ferrochromium[9]	218,000	156,000	197,000	141,000	-20,900	-10
Chromium metal[10]	7,120	7,120	6,670	6,670	-452	-6

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Change based on gross weight quantity of current year compared with that of previous year.

[3]Includes cast irons, welding and alloy hard-facing rods and materials, wear- and corrosion-resistant alloys, and aluminum, copper, magnetic, nickel, and other alloys.

[4]The source for stockpile materials is the Defense Logistics Agency, Defense National Stockpile Center.

[5]Metallurgical grade chromite ore was used up in 2002.

[6]Chromium content estimated using 28.6% chromium.

[7]Chromium content estimated using 23.9% chromium.

[8]Ferrochromium silicon was used up in 2002.

[9]Chromium content estimated using 71.4% chromium.

[10]Chromium content estimated using 100% chromium.

TABLE 3

VALUE OF IMPORTS AND U.S. PRICE QUOTATIONS FOR CHROMIUM MATERIALS[1]

Material		2003 Contained chromium	2003 Gross weight	2004 Contained chromium	2004 Gross weight
Value:[2, 3]					
Chromite ore:					
Not more than 40% chromic oxide	dollars per metric ton	1,830	390	(4)	(4)
More than 40% but less than 46% chromic oxide	do.	300	87	776	239
46% or more chromic oxide	do.	162	52	349	113
Average	do.	168	54	354	114
Ferrochromium:					
Not more than 3% carbon:					
Not more than 0.5% carbon	do.	1,800	1,230	2,130	1,430
More than 0.5% but not more than 3% carbon	do.	936	600	2,150	1,440
Average (less than 0.5% but not more than 3%)	do.	1,630	1,100	2,140	1,430
More than 3% but not more than 4% carbon	do.	(5)	(5)	1,160	604
More than 4% carbon	do.	771	443	1,230	690
Average (all grades)	do.	835	485	1,320	754
Chromium metal	do.	XX	5,270	XX	5,820
Price:[6]					
High-carbon ferrochromium:[7]					
50% to 55% chromium	cents per pound	43.27	XX	68.95	XX
60% to 65% chromium	do.	43.63	XX	68.55	XX
Low-carbon ferrochromium:[7]					
0.05% carbon	do.	73	XX	117	XX
0.10% carbon	do.	62	XX	103	XX
0.15% carbon	do.	60	XX	95	XX
Chromium metal:					
Domestic, electrolytic[8]	do.	XX	450	XX	450
Imported:					
Aluminothermic[8]	do.	XX	184	XX	227
Aluminothermic[9]	do.	XX	186	XX	185

XX Not applicable.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Mass-weighted average based on Customs value and weight of imported material.

[3]Reported by the U.S. Census Bureau.

[4]No imports of not more than 40% chromite ore were reported in 2004.

[5]No imports of more that 3% but not more than 4% carbon ferrochromium reported in 2003.

[6]Time-weighted average based on prices reported by material in trade journals.

[7]The source for ferrochromium prices is Platts Metals Week.

[8]The source for domestic electrolytic and imported aluminothermic chromium metal prices is Ryan's Notes.

[9]The source for imported standard aluminothermic chromium metal prices is American Metal Market.

TABLE 4

U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE[1]

		2003		2004		
HTS[2]	Type	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Principal destinations, 2004
2610.00.0000	Chromite ore and concentrate, gross weight	103,000,000	$7,410	43,100,000	$10,400	China (58.3%); Canada (17.0%); Mexico (12.2%); Sweden (9.8%); Japan (2.0%).
	Metal and alloys, gross weight:					
8112.21.0000	Unwrought chromium powders	293,000	2,700	261,000	3,250	Canada (47.5%); Germany (12.6%); Japan (8.2%); Australia (7.7%); Republic of Korea (7.2%); Mexico (4.7%); Singapore (3.7%); Belgium (2.9%); China (1.8%); Italy (1.1%).
8112.22.0000	Chromium metal waste and scrap	153,000	3,350	125,000	3,320	Japan (60.4%); Singapore (26.2%); Latvia (6.5%); Canada (3.6%); Germany (3.0%).
8112.29.0000	Chromium metal other than unwrought powders and waste and scrap	496,000	5,860	545,000	11,000	Japan (52.7%); Venezuela (14.7%); Singapore (12.4%); Mexico (6.2%); Austria (2.5%); Ireland (2.3%); United Kingdom (2.1%); Germany (1.6%); Canada (1.4%).
	Total chromium metal	941,000	11,900	931,000	17,600	
	Chromium ferroalloys:					
7202.41.0000	High-carbon ferrochromium:[3]					Canada (56.1%); Mexico (33.1%); Brazil (7.2%); Uruguay (2.3%).
	Gross weight	3,180,000	2,720	6,580,000	7,570	
	Contained weight	1,930,000	XX	4,060,000	XX	
7202.49.0000	Low-carbon ferrochromium:[4]					Canada (40.7%); Mexico (15.9%); Brazil (14.2%); Venezuela (8.9%); Sweden (5.2%); United Kingdom (4.7%); Belgium (2.5%); Australia (2.1%); Finland (2.1%); Chile (1.2%); Republic of Korea (1.2%).
	Gross weight	1,230,000	2,000	1,410,000	3,090	
	Contained weight	733,000	XX	852,000	XX	
7202.50.0000	Ferrochromium-silicon:					Mexico (97.6%); Canada (2.4%).
	Gross weight	481,000	511	1,150,000	1,300	
	Contained weight	168,000	XX	403,000	XX	
	Total ferroalloys:					
	Gross weight	4,890,000	5,240	9,140,000	12,000	
	Contained weight	2,830,000	XX	5,320,000	XX	
	Chemicals, gross weight:					
	Chromium oxides:					
2819.10.0000	Chromium trioxide	7,840,000	12,600	10,700,000	14,300	China (34.9%); India (11.8%); Brazil (10%); Chile (9.1%); Republic of Korea (5.8%); Taiwan (4.1%); Thailand (4.1%); Austria (2.3%); Mexico (2.0%); France (1.8%); Hong Kong (1.7%); Netherlands (1.4%); Indonesia (1.3%); Japan (1.3%); Malaysia (1.3%); Canada (1.2%); Colombia (1.0%).
2819.90.0000	Other	2,250,000	8,010	2,130,000	7,840	Canada (30.7%); United Kingdom (19.9%); Brazil (15.4%); Phillipines (3.7%); Taiwan (3.6%); Hong Kong (3.3%); Thailand (2.9%); Japan (2.8%); Australia (2.7%); Mexico (2.7%); Republic of Korea (2.2%); Indonesia (1.6%); Chile (1.4%); Singapore (1.2%); Malaysia (1.1%); China (1.0%).
2833.23.0000	Chromium sulfates	5,440	62	38,500	417	Colombia (58.6%); Hong Kong (25.5%); Switzerland (8.7%); South Africa (1.8%); Mexico (1.5%); China (1.3%); Singapore (1.3%); United Kingdom (1.3%).

See footnotes at end of table.

TABLE 4—Continued

U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2]	Type	2003 Quantity (kilograms)	2003 Value (thousands)	2004 Quantity (kilograms)	2004 Value (thousands)	Principal destinations, 2004
	Chemicals, gross weight—Continued:					
	Salts of oxometallic or peroxometallic acids:					
2841.20.0000	Zinc and lead chromate	104,000	340	74,500	236	Canada (32.1%); Israel (27.4%); El Salvador (12.2%); Mexico (6.9%); Colombia (6.4%); Dominican Republic (5.3%); Trinidad and Tobago (3.9%); Brazil (2.8%); Guatamala (1.3%); New Zealand (1.2%).
2841.30.0000	Sodium dichromate	11,600,000	6,900	21,200,000	12,300	China (22.9%); Japan (27.1%); Canada (14.4%); Mexico (8.3%); Thailand (8.0%); Germany (4.4%); Peru (2.5%); Colombia (2.0%); India (1.9%); Belgium (1.4%); Brazil (1.4%); Ecuador (1.2%); Republic of Korea (1.2%).
2841.50.0000	Other chromates, dichromates, and peroxochromates:					
2841.50.1000	Potassium dichromate	42,400	63	23,400	63	Canada (74.1%); Brazil (13.0%); Estonia (10.6%); Hong Kong (1.6%).
2841.50.9000	Other	412,000	1,290	514,000	1,740	Canada (18.1%); Republic of Korea (16.7%); Kuwait (15.8%); Brazil (14.1%); Mexico (11.1%); Malaysia (9.2%); Argentina (4.1%); Saudi Arabia (3.5%); China (3.2%); France (1.6%).
3206.20.0000	Pigments and preparations, gross weight	867,000	4,610	671,000	3,780	Mexico (31.8%); Canada (31.7%); Colombia (6.7%); Venezuela (5.0%); Taiwan (3.1%); China (2.6%); Republic of Korea (2.4%); Thailand (2.4%); Brazil (1.6%); United Aran Emirates (1.5%); Italy (1.4%); Argentina (1.2%); Netherlands (1.0%).

XX Not applicable.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Harmonized Tariff Schedule of the United States of America code.

[3]More than 4% carbon.

[4]Not more than 4% carbon.

Source: U.S. Census Bureau.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF FERROCHROMIUM, BY COUNTRY[1]

Country	Not more than 0.5% carbon (HTS[2] 7202.49.5090)			More than 0.5% carbon, but not more than 3% carbon (HTS[2] 7202.49.5010)			More than 3% carbon, but not more than 4% carbon (HTS[2] 7202.50.0010)		
	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)
2003:									
China	95	63	$117	--	--	--	--	--	--
Germany	3,990	2,800	7,370	--	--	--	--	--	--
Japan	1,790	1,240	3,750	--	--	--	--	--	--
Kazakhstan	1,530	1,060	1,340	1,100	758	$934	--	--	--
Russia	11,900	8,030	11,200	321	220	345	--	--	--
South Africa	88	59	128	3,920	2,440	1,920	--	--	--
Sweden	--	--	--	--	--	--	--	--	--
Turkey	160	107	241	--	--	--	--	--	--
Zimbabwe	--	--	--	--	--	--	--	--	--
Total	19,500	13,400	24,100	5,340	3,420	3,200	--	--	--
2004:									
China	174	113	300	20	9	42	--	--	--
Germany	4,930	3,490	8,930	63	44	72	--	--	--
India	--	--	--	--	--	--	--	--	--
Japan	2,060	1,450	4,780	--	--	--	--	--	--
Kazakhstan	1,170	788	1,660	2,020	1,400	3,520	--	--	--
Russia	17,900	12,400	24,700	2,100	1,450	2,830	--	--	--
South Africa	5,010	2,730	4,270	1,520	927	1,780	30	16	$18
Turkey	135	92	262	--	--	--	--	--	--
Zimbabwe	--	--	--	--	--	--	--	--	--
Total	31,400	21,100	44,900	5,720	3,830	8,250	30	16	18

Country	More than 4% carbon (HTS[2] 7202.41.0000)			Total (all grades)		
	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)
2003:						
China	20	14	$25	115	76	$142
Germany	340	216	185	4,330	3,020	7,550
Japan	--	--	--	1,790	1,240	3,750
Kazakhstan	126,000	86,900	75,000	129,000	88,800	77,300
Russia	3,610	2,390	2,380	15,800	10,600	13,900
South Africa	207,000	103,000	72,600	211,000	106,000	74,600
Sweden	12	7	7	12	7	7
Turkey	--	--	--	160	107	241
Zimbabwe	29,000	17,500	11,800	29,000	17,500	11,800
Total	366,000	210,000	162,000	391,000	227,000	189,000
2004:						
China	--	--	--	195	122	342
Germany	--	--	--	4,990	3,530	9,010
India	12,900	8,110	10,400	12,900	8,110	10,400
Japan	--	--	--	2,060	1,450	4,780
Kazakhstan	87,000	60,200	84,200	90,200	62,400	89,300
Russia	9,170	6,220	7,560	29,200	20,100	35,100
South Africa	244,000	122,000	145,000	251,000	126,000	151,000
Turkey	--	--	--	135	92	262
Zimbabwe	44,600	26,500	28,200	44,600	26,500	28,200
Total	398,000	223,000	275,000	435,000	248,000	328,000

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Harmonized Tariff Schedule of the United States of America code.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE[1]

		2003		2004		
HTS[2]	Type	Quantity (kilograms)	Value[3] (thousands)	Quantity (kilograms)	Value[3] (thousands)	Principal sources, 2004
	Chromite ore:					
2610.00.0020	Not more than 40% Cr_2O_3:					
	Gross weight	77,000	$30	--	--	
	Cr_2O_3 content	24,000	XX	--	--	
2610.00.0040	More than 40%, but less than 46% Cr_2O_3,:					South Africa (100%).
	Gross weight	7,940,000	692	1,690,000	$404	
	Cr_2O_3 content	3,370,000	XX	761,000	XX	
2610.00.0060	46% or more Cr_2O_3:					South Africa (100%).
	Gross weight	165,000,000	8,570	151,000,000	17,100	
	Cr_2O_3 content	77,400,000	XX	73,600,000	XX	
	Total:					
	Gross weight	173,000,000	9,290	153,000,000	17,500	
	Cr_2O_3 content	80,800,000	XX	74,400,000	XX	
	Metals and alloys:					
7202.50.0000	Ferrochromium-silicon:					Kazakhstan (86.9%); Russia (9.5%); South Africa (3.6%).
	Gross weight	38,700,000	24,900	30,600,000	31,500	
	Cr_2O_3 content	16,200,000	XX	12,500,000	XX	
	Chromium metal, gross weight:					
8112.21.1000	Unwrought chromium powders	1,810,000	11,600	1,350,000	9,070	Russia (47.1%); Japan (18.3%); China (17.9%); Spain (8.9%); Germany (5.8%); Taiwan (1.1%); France (0.5%).
8112.22.0000	Waste and scrap	283,000 r	1,510 r	74,000	491	Japan (54.5%); China (23.0%); Singapore (14.2%); Germany (5.4%); Russia (2.8%)
8112.29.0000	Other than waste and scrap	6,480,000	32,000 r	8,200,000	46,500	Russia (30.9%); United Kingdom (28.0%); France (22%); China (18.5%).
	Total	8,570,000	45,200	9,630,000	56,000	
	Chemicals, gross weight:					
	Chromium oxides and hydroxides:					
2819.10.0000	Chromium trioxide	14,100,000	18,900	7,000,000	10,500	Kazakhstan (33.4%); United Kingdom (28%); Turkey (24.4%); South Africa (7.4%); China (4.6%); Taiwan (1.5%).
2819.90.0000	Other	2,510,000	7,600	2,960,000	8,400	Japan (41.2%); China (40.8%); Germany (7%): United Kingdom (5.6%); Hong Kong (1.7%); Spain (1.1%); Taiwan (0.9%); Russia (0.7%); Poland (0.6%).
2833.23.0000	Sulfates of chromium	162,000	194	111,000	161	United Kingdom (100%).
	Salts of oxometallic or peroxometallic acids:					
2841.20.0000	Chromates of lead and zinc	153,000	307	710,000	1,630	Republic of Korea (45.2%); Austria (33.1%); Norway (12%); Colombia (6.1%); Japan (3%); Canada (0.6%).
2841.30.0000	Sodium dichromate	3,020,000	1,440	494,000	380	South Africa (64.5%); China (27.4%); Turkey (8.1%).
2841.50.0000	Other chromates and dichromates; peroxochromates:					
2841.50.1000	Potassium dichromate	102,000	142	105,000	187	Kazakhstan (91.1%); Germany (6.9%); India (1.0%); Japan (1.0%).
2841.50.9000	Other	377,000	862	570,000	1,240	Austria (58.4%); Republic of Korea (28.7%); China (11.4%); France (1.6%).
2849.90.2000	Chromium carbide	203,000	2,340	138,000	1,630	Japan (42.5%); United Kingdom (34.2%); Canada (11.4%); Germany (10.7%); China (1.1%).

See footnotes at end of table.

TABLE 6—Continued

U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE[1]

		2003		2004		
HTS[2]	Type	Quantity (kilograms)	Value[3] (thousands)	Quantity (kilograms)	Value[3] (thousands)	Principal sources, 2004
	Pigments and preparations based on chromium, gross weight:					
3206.20.0010	Chrome yellow	5,560,000	$13,000	5,300,000	$12,400	Canada (49.7%); Republic of Korea (29.1%); Mexico (12.1%); Hungary (4.6%); Colombia (3.1%); Germany (0.6%).
3206.20.0020	Molybdenum orange	987,000	4,310	1,030,000	4,760	Canada (91.5%); Colombia (4.1%); Mexico (2.7%); Japan (0.9%).
3206.20.0030	Zinc yellow	657	5	15,600	29	Mexico (100%).
3206.20.0050	Other	1,740,000	4,390	1,200,000	2,980	France (52.8%); China (30.5%); Germany (8%); Poland (4.8%); Canada (2.2%); Italy (0.5%); Spain (0.5%).

[r]Revised. XX Not applicable. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Harmonized Tariff Schedule of the United States of America code.

[3]Customs import value generally represents a value in the foreign country and therefore excludes U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise into the United States.

TABLE 7

WORLD PRODUCTION CAPACITY OF CHROMITE ORE, FERROCHROMIUM, CHROMIUM METAL, CHROMIUM CHEMICALS, AND STAINLESS STEEL, AND APPARENT CONSUMPTION IN 2004[1]

(Thousand metric tons of contained chromium)

Country	Ore	Ferrochromium	Metal	Chemicals	Stainless steel	Apparent consumption[2]
Afghanistan	2	--	--	--	--	--
Albania	48	22	--	--	--	12
Argentina	--	--	--	13	--	20
Australia	77	--	--	--	--	45
Austria	--	--	--	--	8	111
Belgium	--	--	--	--	120	104
Brazil	123	113	--	--	96	159
Canada	--	--	--	--	9	23
China	66	330	6	70	493	828
Cuba	17	--	--	--	--	13
Egypt	--	--	--	--	3	(3)
Finland	189	139	--	--	221	163
France	--	--	7	--	148	117
Germany	--	17	1	--	298	247
Greece	(3)	--	--	--	--	37
India	888	275	(3)	4	255	489
Indonesia	--	--	--	--	--	-2
Iran	50	12	--	2	--	(3)
Italy	--	--	--	--	298	216
Japan	--	11	1	17	714	592
Kazakhstan	990	683	2	37	--	353
Korea, Republic of	--	--	--	--	425	300
Macedonia	--	--	--	--	--	(3)
Madagascar	40	--	--	--	--	11
Norway	--	--	--	--	--	(3)
Oman	9	--	--	--	--	-4
Pakistan	36	--	--	3	--	(3)
Philippines	8	--	--	--	--	-24
Poland	--	--	--	--	--	4
Russia	97	282	16	31	26	234
Slovakia	--	1	--	--	--	(3)
Slovenia	--	--	--	--	20	(3)
South Africa	2,300	1,610	--	23	120	515
Spain	--	--	--	--	204	115
Sudan	14	--	--	--	--	3
Sweden	--	86	--	--	119	139
Taiwan	--	--	--	--	289	231
Turkey	164	62	--	17	--	-5
Ukraine	--	--	--	--	88	(3)
United Arab Emirates	9	--	--	--	--	(3)
United Kingdom	--	--	7	44	85	93
United States	--	20	3	38	425	245
Vietnam	45	--	--	--	--	-59
Yugoslavia	--	--	--	--	51	--
Zimbabwe	214	165	--	--	--	64
Total	5,390	3,830	43	299	4,520	XX

XX Not applicable. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Apparent consumption is chromite ore production plus chromite ore, ferrochromium, and chromium metal net imports. Net imports are imports minus exports. Based on data reported by the International Chromium Development Association.

[3]Less than ½ unit.

TABLE 8

CHROMITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of gross weight)

Country[3]	2000	2001	2002	2003	2004
Afghanistan[4]	5,345	5,682	6,136 r	6,364 r	-- e
Albania[5]	120,400	86,000	91,000	95,000 r	158,392
Australia	90,000	11,800	132,665	138,826	265,987
Brazil[6]	550,000	409,049 r	283,991 r	404,477 r	462,755
Burma[e]	227 r	307 r	318 r	341 r	-- e
China[e]	208,000	182,000	180,000	200,000	200,000
Cuba	56,300	50,000	46,000	34,000 r, p	34,000 e
Finland	628,414	575,126	566,090	549,040	579,780
India	1,946,910	1,677,924	2,698,577	2,210,000	2,948,944
Iran	153,000	104,905	80,000	120,000	183,171
Kazakhstan	2,606,600	2,045,700	2,369,400	2,927,500	3,267,000
Macedonia	-- r	-- r	-- r	-- r	--
Madagascar	131,293	23,637	11,000	45,040	77,386
Oman	15,110	30,100	27,444	13,000	18,585
Pakistan	119,490	64,000	62,005	98,235	10,000
Philippines	26,361	26,932	23,703	24,000 e	25,000
Russia	92,000	69,926	74,300	116,455	320,200
South Africa	6,622,000	5,502,010	6,435,746	7,405,391	7,625,545
Sudan	28,500 r	20,500 r	14,000 r	37,000 r	26,000
Turkey	545,725	389,759	313,637	291,793 r	436,639
United Arab Emirates[e]	30,000	10,000	--	--	7,089
Vietnam[e]	76,300 [7]	70,300 r	80,000	120,000 r	150,000
Zimbabwe	668,043	780,150	749,339	637,099 r	668,391
Total	14,700,000 r	12,100,000	14,200,000	15,500,000	17,500,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1]World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through June 20, 2005.

[3]Figures for all countries represent marketable output unless otherwise noted.

[4]Gross weight estimated assuming an average grade of 44% chromic oxide (Cr_2O_3).

[5]Direct shipping plus concentrate production.

[6]Average chromic oxide (Cr_2O_3) content was as follows: 2000—46.0%; 2001—42.5%; 2002—40.1%; 2003—29.2% (revised); and 2004—30.0% (estimated).

[7]Reported figure.

TABLE 9

FERROCHROMIUM: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of gross weight)

Country	2000	2001	2002	2003	2004[e]
Albania	12,500	11,900	22,100	37,800	34,650 [3]
Brazil[4]	172,443 [r]	110,968 [r]	134,140 [r]	204,339 [r]	204,626 [3]
China[e]	450,000	310,000	330,000	500,000	600,000
Croatia	15,753	361	-- [e]	-- [e]	--
Finland	260,605	236,710	248,181	250,490 [r]	264,492 [3]
Germany	21,600	19,308	20,018	18,318	24,857 [3]
India[5]	376,693	267,395	311,927	468,677	527,100 [3]
Iran	11,505	8,430	15,000 [e]	17,000	17,000
Japan[4]	130,074	111,167	91,937	19,427 [r]	16,600
Kazakhstan	799,762	761,900	835,800	993,000	1,050,000
Norway	153,500	82,600	61,100	-- [e]	--
Russia	274,000	210,600	210,000	357,000	454,000
Slovakia	17,702	5,968	5,695	1,924	1,784 [3]
South Africa[6]	2,574,000	2,141,000	2,351,122	2,813,000 [r]	3,100,000
Spain[e]	905 [6]	--	--	--	--
Sweden	135,841	109,198	118,823	110,529	128,191 [3]
Turkey	97,640	50,735	11,200 [e]	35,393	33,686 [3]
United States[7]	W	W	W	W	W
Zimbabwe	246,324	243,584	258,164	245,200	193,077 [3]
Total	5,750,000	4,680,000	5,030,000 [r]	6,070,000 [r]	6,650,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table inculdes data available through June 20, 2005.

[3]Reported figure.

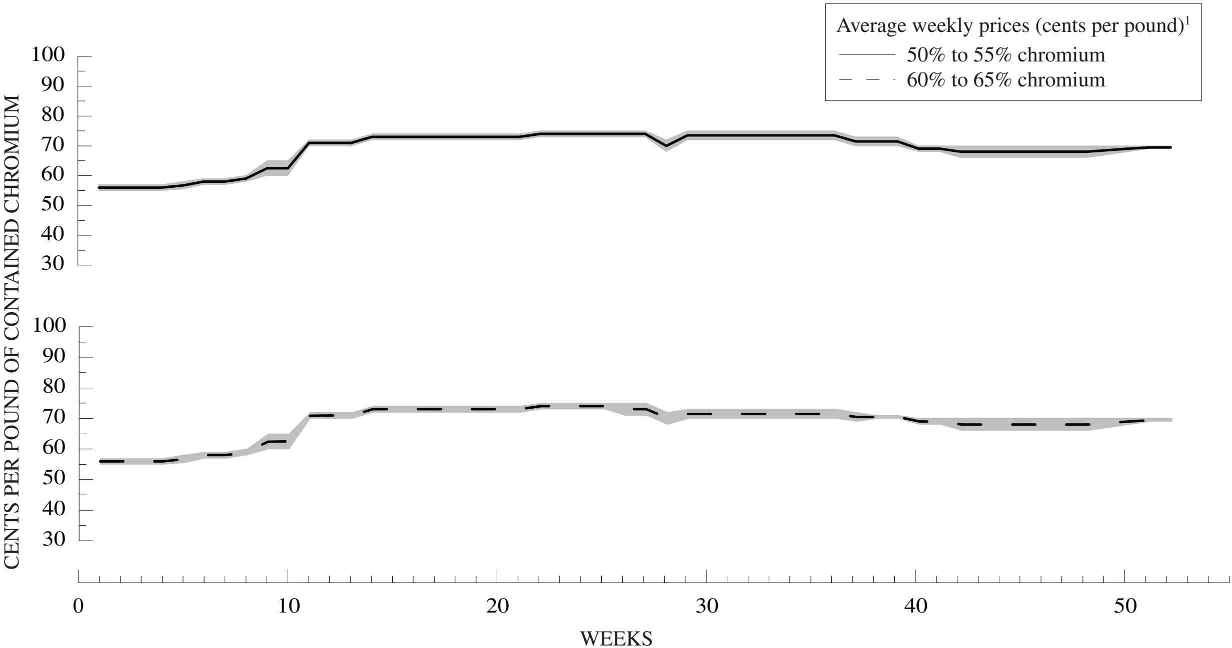
[4]Includes high- and low-carbon ferrochromium.

[5]Includes ferrochrome and charge chrome.

[6]Includes high- and low-carbon ferrochromium and ferrochromiumsilicon.

[7]Includes chromium metal, high- and low-carbon ferochromium, ferochromiumsilicon, and other chromium materials.

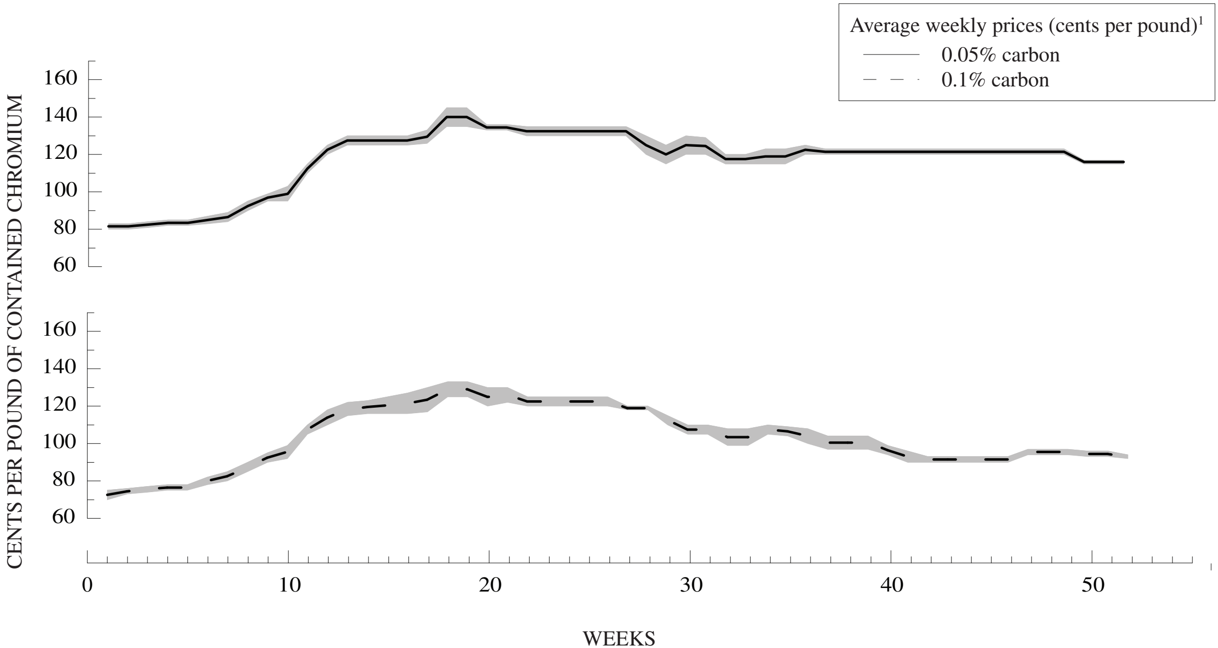
FIGURE 1
U.S. IMPORTED HIGH-CARBON FERROCHROMIUM IN 2004



[1]Average weekly price shown against price range background.

Source: Platts Metals Week.

FIGURE 2
U.S. IMPORTED LOW-CARBON FERROCHROMIUM IN 2004



[1]Average weekly price shown against price range background.

Source: Platts Metals Week.